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... A. R. Croft

Gulley Erosion Surveying With Aerial Photographs
... C. L. Guffon

Soil Conservation in Israel
... Yehuda Lowe

Book Reviews: Introduction to Economics for Agriculture; Forest Resources of Montana; also four new "True-To-Life" books by R. W. Eschmeyer.

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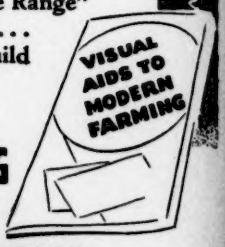

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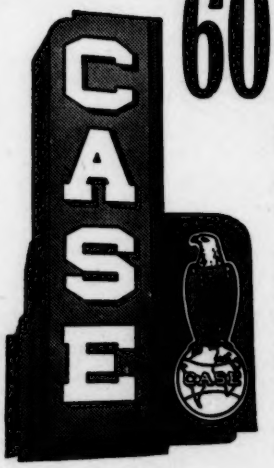

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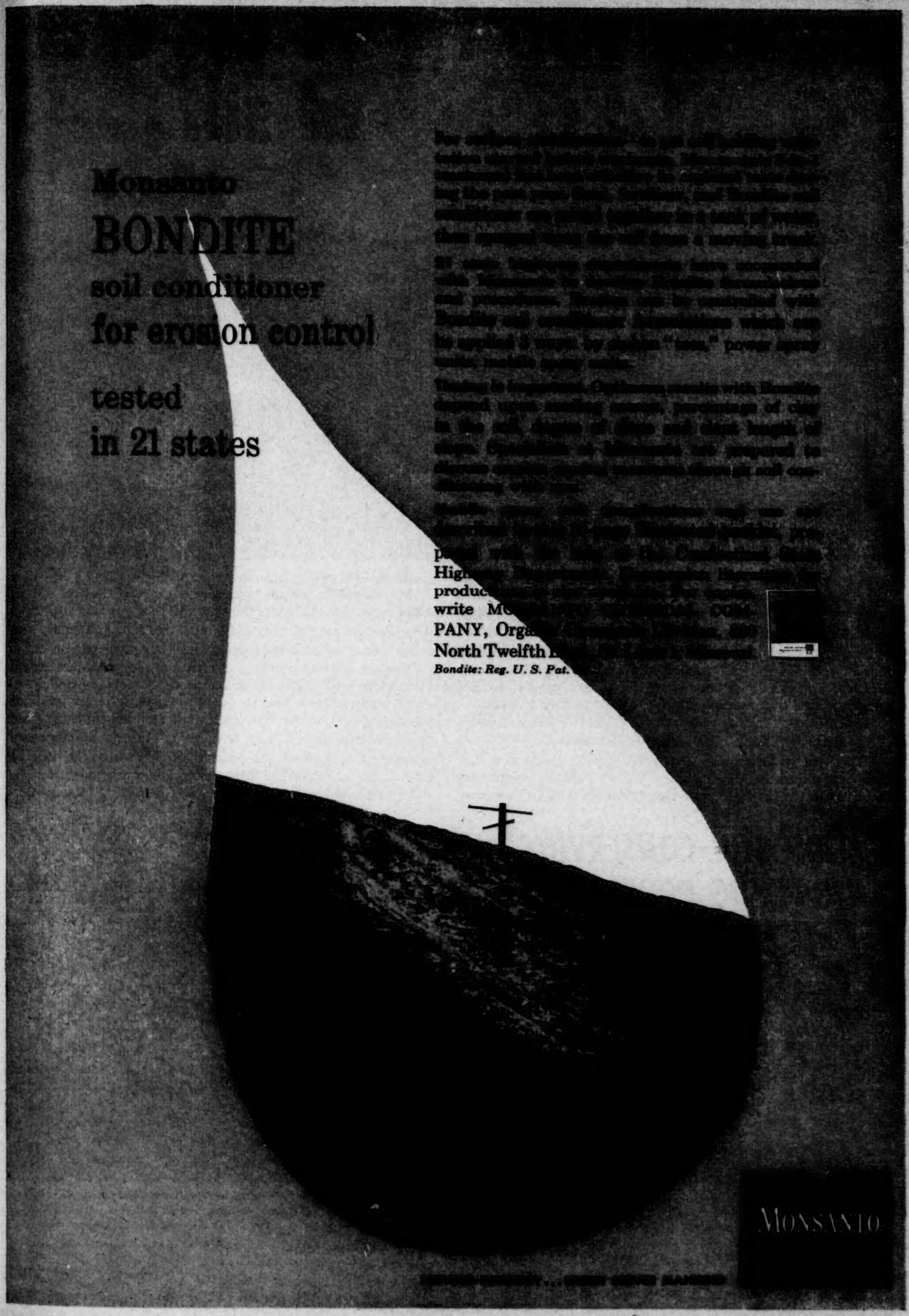
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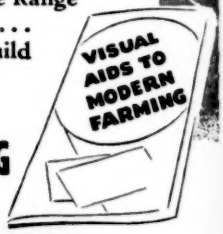

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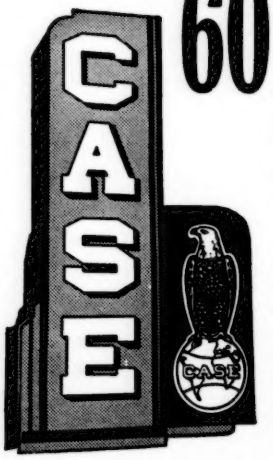

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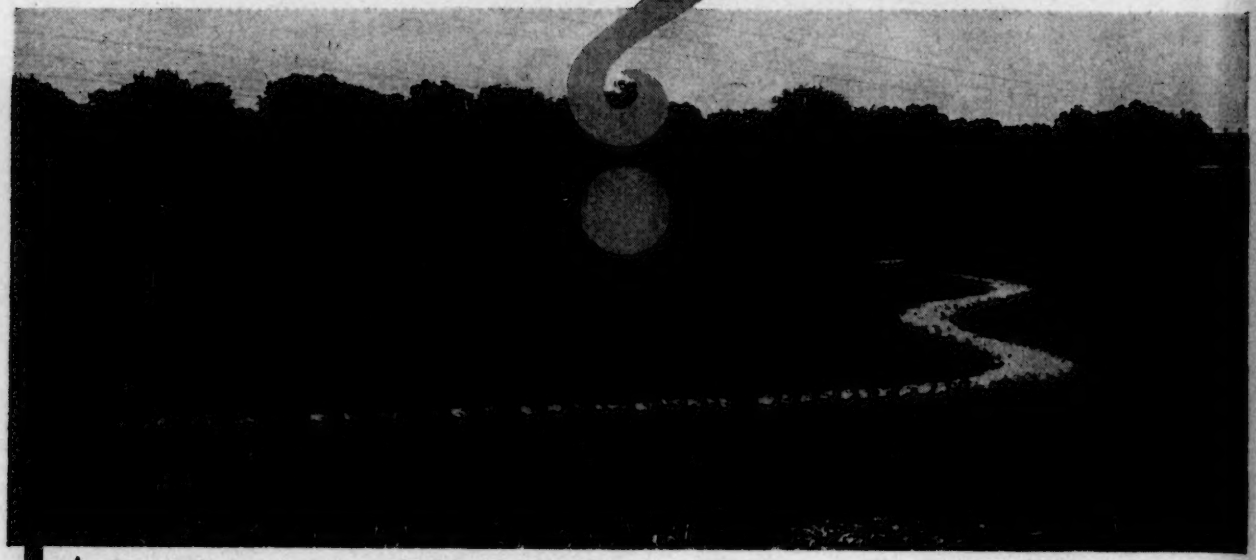

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Journal of SOIL AND WATER CONSERVATION

VOLUME 8
NUMBER 4

TO ADVANCE THE SCIENCE AND ART OF GOOD LAND USE

This JOURNAL is the official organ of the Soil Conservation Society of America. It is owned, edited, and published bi-monthly by the Society.

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—Photo by Gordon S. Smith

Cover. ***The young conservationist standing in this fine cover crop of wheat, vetch and voluntary rye is Sidney Ripple of Millersville, Maryland. He is the son of John Ripple, a tobacco farmer and cooperator with the Anne Arundel County Soil Conservation District.***

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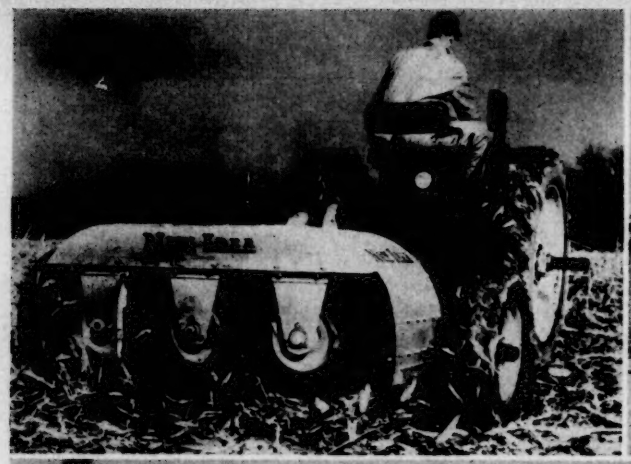

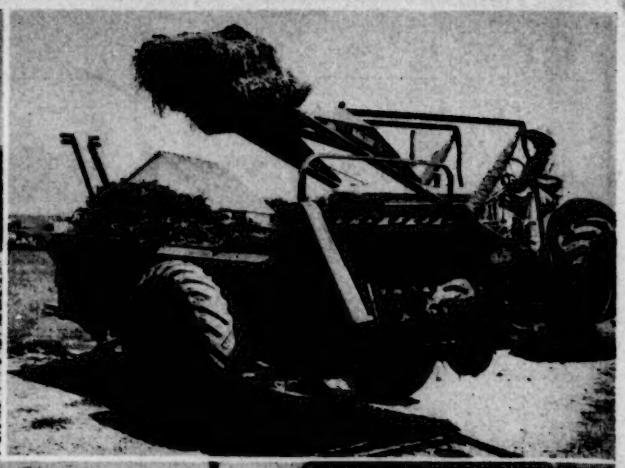

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Above right: New Idea-Horn loader has fast lift, high reach. Handles loads up to 2,500 lbs. Low profile permits working in cramped quarters. 10 easy-on attachments do 101 other jobs. Fits more than 80 tractor models.

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You need these machines for humus-hungry crops and soils.

What Do You Mean: 'Soil Conservation'?

WILLIAM R. VAN DERSAL

William R. Van Dersal

Here for the first time are brought together the diverse answers of many conservationists to the question: What is soil conservation? Not until the Soil Conservation Society of America set up a technical committee on the meaning of soil conservation had such a round-up of opinion been attempted. W. R. Van Dersal, who was asked to serve as chairman of this committee, chose in unique fashion to have his "committee" consist of outstanding figures in the conservation world whose thinking he would canvass and collate. The provocative result is in part presented below with the second half of the summary to follow in the September issue.

ANYONE WHO USES the phrase "soil conservation" would seem to do so at his own risk. The phrase has had a considerable history, and its second word, *conservation,* has frequently been through the storm centers of bitter controversies. Like many another much-used word or phrase in our language, it gives evidence of becoming somewhat shopworn. It has been used by various groups to express such different faiths or beliefs, it has been stretched to encompass such a multitude of virtues, and hence now has such a multitude of meanings, that by this time it not only means many things to many people, but it can be made to mean just about what anyone wants it to.

The word "conservation" derives originally from two Latin words meaning literally "to keep guard," and as applied to soil it means then, "to keep guard over soil." "Conservation" has been applied to all sorts of things, wildlife, forest, minerals, oil, water, food, human beings, money, electricity, energy, matter, and many other materials, forces, beings, and things. There seems no question but that it was first used in the United States in its original meaning of keeping guard. We meant just that when we talked about such ideas as forest conservation or wildlife conservation early in the present century. We were, at that time, getting fed up with the era of extravagant exploitation of virgin timber and beautifully-plumed birds. We wanted to keep guard over some of these things to protect them from further exploitation, or indeed, extirpation. We said then that some of these things ought to be passed on to our children to enjoy, untouched, undefiled, just as they were originally. An excellent expression of this concept is contained in the following excerpt from Theodore Roosevelt's writings:

"There can be nothing in the world more beautiful than the Yosemite, the groves of giant sequoias and redwoods, the canyon of the Colorado, the three Tetons; and our people should see to it that they are preserved for their children and their children's children forever, with their majestic beauty all unmarred. . . ."

This concept of non-use, or of protecting or defending from exploitation, is still attached to the word "conservation," and the word is used in its original meaning when it is used to express the kind of preservation Roosevelt was talking about. For example, the phrase "wildlife conservation" is used in this original sense when applied to activities such as setting up a refuge for a rare animal. Likewise, "forest conservation," in the original sense, would be such a thing as setting aside a tract of original forest as a wilderness area.

Conservation Not Necessarily Wise Use

Now, when the word "conservation" is attached to something we must use, especially when we change it in the very act of using it, we begin to get into difficulties. No matter how much we protest that we mean well, and that the use we propose is *wise* use, other people still think we mean what *they* do, i.e., to protect from use. Emmanuel Fritz noted in the Journal of Forestry a year ago that "we occasionally enroll a student who expresses

Wm. R. Van Dersal, a member of the SCSA and chairman of its technical committee on the meaning of soil conservation, is Regional Chief of Operations, Soil Conservation Service, Portland, Oregon. Dr. Van Dersal is the author of "The American Land" and numerous books, pamphlets and papers.

dismay when he learns that we teach *lumbering* as well as forest management and protection." "Lumber comes from trees," remarks Professor Fritz, "and to get it, trees must be *cut*."

Conservation has been widely defined as "wise use." But this definition has two things wrong with it. The first is that *use*, as we have just noted, is almost the reverse of the original meaning of conservation. The second is that "wise" depends upon whose wisdom we rely upon for decision. Thus, the bird-walker may consider it wise merely to observe; the ornithologist considers it wise to collect a series of specimens; the sportsman considers it wise to kill within legal limits; the plume-hunter considered it wise to kill without limit. One may draw similar parallels in the wise use of forests, parks, and other natural resources. Indeed, present-day quite intelligent farmers may consider it wise to put up with disastrous erosion in order to grow high-value wheat. To conservationists this is unwise; farmers should grow livestock instead, and keep their land covered with grass.

The idea of using while conserving is an outgrowth of the original meaning of "conservation" in the soil field. A reading of the historical record of American agriculture shows quite clearly that the so-called soil conservation movement of the present day began with efforts to *prevent* or *control* soil erosion. These efforts began because erosion damage became alarming and widespread. Earliest practices advocated to stop erosion included hillside ditching, contour plowing, and terracing, all mechanical measures aimed at preventing water from washing soils downhill. Restoration or reclamation of erosion-damaged lands was also advocated, by the planting of grass or trees. Practices designed to keep the soil covered or to add organic matter, received emphasis, not because of their value in improving crop production but because they could enable soils to resist erosion better.

With these ideas in mind, the phrase "soil conservation" would seem to have been used with a meaning only slightly extended beyond the original meaning. President Taft used the phrase in just this way in 1911 when he addressed the National Conservation Congress at Kansas City. He said:—"The first great step that has to be taken in reformed agriculture is the conservation of the soil. Under our present system the loss to the farms in this country by the erosion of the soil is hardly to be calculated. Engineers have shown how much is carried down the great rivers of the country and is deposited as silt each year at their mouths. The number of cubic yards staggers the imagination. The question is how this can be prevented, as it must be, because the soil which is carried off by this erosion is generally the richest and the best soil of the farms which are thus denuded."

The words "prevent" or "control" are not exact synonyms of "to keep guard" but their meaning is nevertheless fairly close, and when Taft talked about preventing erosion, his meaning was close to the original meaning of the words "conservation of the soil." In the same spirit, the Congress of the United States in setting up the *Soil Conservation Service*, started out by saying that "it is hereby declared to be the policy of the Congress to provide permanently for the *control* and *prevention* of soil erosion. . . ."

Broader Concept of Soil Conservation

As is well known, of course, soil conservation very rapidly became more than erosion control or prevention. A parallel expansion has occurred in the fields of wildlife conservation and forest conservation, to name only two related fields. In the more modern sense of the term, "soil conservation" is no longer restricted to the preventive or keeping-guard phases. Nor is it surprising that the phrase should grow, since the activities to which it is attached, have in themselves grown much broader in scope than originally conceived.

At the present time, it seems clear that we must choose one of two courses of action. If we continue to use the phrase, we must recognize that it carries its original meaning along with it, and that people may think we are expressing the idea of "keeping guard over soil," or of erosion control. If we feel that this idea restricts the meaning we intend, then we must either explain our broader concept or find another word to do it.

So far, no one seems to have come up with a better word or phrase. "Soil Conservation" is well-entrenched; millions of people use it, and although there is a variety of meanings attached to it, there would seem considerable difficulty in abandoning the phrase unless we chanced upon a new one with greater popular appeal that could easily replace it. Under these circumstances, and with due regard for its historical development, it is proposed here that we take the course of giving the phrase a new meaning, attempting to get the broader meaning understood and accepted everywhere.

Cross-Section of Opinions Sought

During 1952 correspondence was carried on with people in many places in the United States who were interested in soil conservation in a variety of ways. These people included professionals, governors, writers, legislators, congressmen, senators, editors, teachers, clergymen, farmers, and others. They were asked to put in writing their conception of the meaning of soil conservation. The intent was to get a rough cross-section of opinion which could then be given to the membership at large of the Soil Conservation Society of America for review. The Society, of course, has a considerable interest in the

phrase, which is used both in its name and in the title of its JOURNAL.

Now it is interesting to note that with possibly one or two exceptions, all the people who sent in their definitions believe that soil conservation means, or should mean, more than erosion control. They say in one way or another that soil conservation as *they* see it, embraces at least three ideas, of which the first is to prevent land from being damaged, the second is to repair damage already done, and the third is to make the land as productive as possible.

To illustrate these points, here are quotations from some of the letters:

From Chester C. Davis, associate director of the Ford Foundation: "When I use the term 'soil conservation,' I mean the conservation, development and wise use of our land and water resources in a continuing program that will not only protect the soil permanently against physical loss or deterioration, but will repair damage already done and enhance the land's productivity. Within those limits a soil conservation program, whether it is applied to crops or range or forest, should encourage the fullest profitable use of the land for the purpose to which it is best suited."

From Fred A. Wirt, advertising manager of the J. I. Case Company: "I interpret 'Soil Conservation' to mean good farming practices; continued improvement in the productive capacities of our soils; an increase in the availability of water for man, livestock and growing plants, and larger supplies of lumber for the needs of a growing population and thriving industries."

From Arthur B. Langlie, governor of the State of Washington: "To me, soil conservation is that science of soil management which has for its ultimate goal the most profitable, productive use of the soil that can be had and still maintain or improve the quality and quantity of the resource."

From the Honorable Jamie L. Whitten, member of the House of Representatives of the Congress of the United States: "Any definition of the term, as it applies to our Country must provide for 'use of the soil' and with our ever-growing population, we must use our soil and must seek to leave the soil and those things that are a part of it in as good shape after a period of usage as it was at the beginning. Any increase in soil fertility above that at the outset is to be preferred. A short definition might then be, 'Soil Conservation is a system of soil practices whereby the soil is used to provide food, clothing and shelter in such a way as to retain fully its ability to produce, and in the United States such system must include restoration of the millions of acres of eroded and exhausted land'."

From Professor R. I. Throckmorton, dean and director emeritus, Kansas State College: "To me, soil conservation consists of those practices which will result in obtaining maximum economic production and at the same time maintain or improve the total capacity the soil can produce.

"Soil conservation is more than soil fertility. It is more than erosion control. It is more than moisture control. It is more than improving soil structure. It is more than good soil management. It is a combination of soil fertility, erosion prevention, moisture conservation, good fertility practices, and good soil management aimed at maximum current economic production and the conservation of soil for future generations."

Some Farmer Opinions

From E. O. Moore, practicing conservation farmer at Dexter, New Mexico, and president of the New Mexico Association of Soil Conservation Districts: "I think first of all the thing we are trying to accomplish is not soil conservation at all, but a perpetual source of adequate supply of the necessities of life, for an ever-expanding population.

"In accomplishing this objective, the conservation of soil and water is one of the necessary sub-accomplishments. Others are agricultural research, distribution and transportation, research in the manufacture of more and better food, clothing and shelter items and the whole field of agricultural chemistry, and improvement.

"But Soil Conservation, as we who are trying to do something about guaranteeing this perpetual and adequate supply of food and fibre know it, is, I think, the use, treatment and care of the soil, (and water) which will result in the very highest production of needed materials as long as there are people on the earth to use them.

"This may be said more quickly by the statement that soil conservation is one phase of Proper Land Use, which of course implies not only proper land husbandry, but also a selection of soil products to be grown by the farmer which would fit the market demand and so would not require any sort of price support for their profitable sale by the producer. It is inevitable that Proper Land Use would imply a safety from deterioration, either of erosion of the top soil, or depletion of the soil fertility."

From Gerhard Koehler, a practicing soil conservation farmer at Yoakum, Texas: "Soil Conservation is an honest and fair treatment of the land, which man has practiced to restore soil fertility and save its elements from erosion. Honest with the soil in that it is not unduly robbed of fertility without replenishment of these elements through legumes and fertilizers. Fair in that it is protected from erosion by a terrace system, contour farming and natural protection such as vegetation. With

an eager desire to practice Soil Conservation as I have described here we not only benefit ourselves as well as the soil but it prospers everyone."

From G. N. Winder, a stockman of the Two Bar Ranch Company, at Denver, Colorado: "Any discussion of soil conservation must lead into consideration of the broader field of true conservation, on which the maintenance of the soil is only one phase. To me, true conservation means to obtain the maximum of production from the land with a minimum of damage to our soil and water resources. It is possible to have soil or water conservation without getting true conservation.

"I believe that by proper land and water management we can obtain a high level of production and still maintain and even increase our soil and water facilities."

From Edwin W. Jones of the firm of consulting engineers, G. W. Jones and Sons, at Huntsville, Alabama: "Soil conservation to us is the application of proven practices to the land which will preserve or restore for the present generation what was left to us by our forefathers, and at the same time constantly enrich the soil for future generations. A reasonable profit to the owner of the land can still be made even though the maximum in soil conserving practices is carried out."

Other Opinions

From Stuart Chase, noted author, Georgetown, Connecticut: "When I plant grass on high slopes, and trees on steeper slopes, and build gullies with check dams, I am practicing what I call 'Soil Conservation.'

"When I add fertilizer to my vegetable garden, or lime, or this new synthetic humus, to increase the yield of my corn or beets or tomatoes, I'm practicing more efficient agricultural production.

"As a student of semantics I am aware that there is no hard and fast line between the two operations. If agricultural methods which I have practiced have depleted the soil, the fertilizer may help restore it to its original richness, and thus be a kind of conservation. However, as the field is so wide, I tend to think of conservation as any method to keep good topsoil out of the Gulf of Mexico."

Elmer T. Peterson of the Daily Oklahoman-Oklahoma City Times, and author of "Big Dam Foolishness," says: "One way of answering your question is that I find it impossible to answer without saying that soil conservation is not enough. We are considerably handicapped in our crusade by frequent failure to emphasize the fact that we have to save water as well as soil, otherwise the saving of soil is almost meaningless. There is great need of linking two concepts together, so it means 'Soil-and-Water Conservation.'

"The hydrologic cycle should be better described, and the science surrounding that cycle should be seen and exercised in the applied form, not as an academic study. Biology is intimately entangled in this hydrologic cycle. The means thus far taken to slow up the hydrologic cycle is an orderly way, by insoak, recharge, use of vegetation, etc., are crude. So when I speak of soil conservation I speak of a restoration of Nature's own slowly functioning hydrologic cycle, supplemented by a few man-made devices."

From Kent Leavitt, former president of the National Association of Soil Conservation Districts: "My real feelings in this matter are centered around the proper land use idea, because this approach appeals to me. Conservation is a defensive word. But once you are attracted into this field of endeavor by the urge to conserve or protect some particular element of our economy, be it land or soil or water or a great forest, you suddenly find yourself in an aggressive mood which drives you on to the much more satisfactory vocation of developing a better and more permanently beneficial use of whatever it is that nature has made available.

"From our own little farm operation we know by experience that by practicing proper land use methods we are developing, restoring, increasing and using the potential of our land resources. We also gain the knowledge that this can be done in a practical and profitable way. Profitable not only to us who are producers but also to the ever-increasing consuming public. Profiitable too for the coming generations who, if they continue what we started, will find this and other parts of our country, where 'Conservation' work has been carried out, a better place in which to live."

From Fairfield Osborn, president of the Conservation Foundation: "By conserving the soil we are aiming to keep up the land's maximum capacity to produce and to preserve this land for use by future generations. In other words, by advocating soil conservation, we advocate the adoption and wide utilization of measures designed to prevent our soils from being 'mined' by destructive agricultural practices." He goes on to say, incidentally that soil conservation "clearly means many things to many people—but that is true of most things about which everyone has an opinion."

Paul Sears, author, and chairman of the Yale University Conservation Program, writes that soil conservation is "the kind of land use and management which will safeguard the soil and its related resources as capital wealth while insuring the maximum returns consistent with that objective."

Soil Conservation and Good Farming

From these quoted portions of letters, which embody the essence of the replies, it may be concluded that the

idea of making land as productive as possible has been added to the original meaning of soil conservation by these writers. This idea, when combined with the idea of keeping guard over soil, results in a meaning that is very close to what people mean by good farming or good husbandry. In fact, Cecil Hagen, managing editor of the Pacific Northwest Farm Quad, makes this point in his letter when he says: "Our editorial handling of soil conservation, which in recent years has become one of our main subject matter fields, is based on the premise that soil conservation is essentially nothing more than good farming. We haven't worried much about an exact definition, or even a broad one. Our definition would be broad, and something along these lines: "A system of farming that will maintain or improve the soil as a renewable resource."

A point of view bearing on this is expressed by the English author, E. V. Jacks' on page 100 of Vanishing Lands, published in 1939. "There is nothing new," he says, "in the idea of soil conservation. Soil conservation is as old as, and in former times was almost synonymous with, agriculture although nobody used the synonym which is a recent American invention. Good husbandry consists not only in producing but in continuing to produce good crops. If we wished to distinguish between agriculture and soil conservation, we might define agriculture as cultivation for the present and soil conservation as cultivation for future production. Good husbandry combines agriculture and soil conservation."

In the light of present-day opinions, as expressed in the letters quoted, the trend is to make soil conservation synonymous with agriculture, as Jacks' believes it was in former times. We apparently no longer wish to distinguish between agriculture, good farming, good husbandry, and soil conservation, but rather to have soil conservation include them all. To clinch this idea, note what Francis C. Lindsy has to say. He is an assemblyman of the California Legislature, recently elected as area vice president of the NASCD. He writes: "Soil Conservation is *any act, any practice,* or *any treatment,* that would in any way improve the *condition,* the fertility or productivity of the soil. To explain, I believe that the whole ecology of plant and animal life must be considered; everything that lives on, or in, or uses the soil. We cannot say that letting nature take her course will do the job because nature often has prolonged droughts, fires, and terrific storms, which do as much damage as improper use by man. In other words, the control of erosion, the conservation of wildlife, conservation of water, the proper education of the farmer, the development of new agricultural implements, new crops, new strains of crops, and the providing of incentives for better farming, all have their place in good soil conservation.

"I know that many people disagree with me and that they think my definition of soil conservation takes in too much territory. But I believe that is exactly what it is intended to do; to be the term that we can gather up all others under, and place them under one heading. A soil conservation plan that does not take under consideration water conservation, wildlife conservation, man's use, as well as the structures that are needed, such as dykes, diversions, ditches and terraces, is not a complete plan."

To add to this all-inclusive idea, William Vogt, author of "Road to Survival," and national director of the Planned Parenthood Federation of America, Inc., writes that soil conservation "is, in the first place and primarily an integrated process and, equally important, it seems to me, a long range process. It conserves not so much soil fertility in the sense of a medium that will produce heavy crops, perhaps by means of a process that I have called geoponics; it is the maintenance of fertile soil in the sense of the total soil environment which includes trace elements and soil fauna and flora in a structural relationship as near as possible to the optimum to meet the demands made on the land.

"Because it is an integrated process made up of dependent variables it must be related to the total environment in which the land is used and thus must carry a date—be related to time. By this I mean that land that is so limited in its productive capacity that it cannot be economically used with a U. S. population of 150 million may, with a population of 200 million, especially as even-greater overseas demands are made upon us, become cultivable even though it requires an increased input of capital and labor and results in a more costly crop that may help to lower our living standard. If we ever reach the man-land ratio in this country that India, for example, has, soil conservation will be a different process than it is today.

"It is largely in the integration of its operations and its relationship to the total environment, it seems to me, that soil conservation differs from good agriculture. Soil conservation is interested in far more than crops or even preservation of the land on a given farm. It should, I believe, be concerned with water tables, with forest products, with wildlife, and especially with control of the hydrologic cycle. To a soil conservationist what happens in South Dakota as it affects what happens in Missouri is quite as pertinent as what happens on the farm. This requires the adjustment of land use practices to permit optimum infiltration, maintain soil structure, etc. Eventually, it appears to me, the cooperative attitude of the soil conservation district should be extended to entire watersheds. Unless something of that sort is done it is going to be very difficult to end dependence on the big dams."

(*To be Continued in September Issue*)

Water Management on Rangeland: A Responsibility Of Range Managers

A. R. CROFT

Owners and managers of range lands in the West must assume responsibility for management of the water that falls as precipitation on these lands. The water that originates on range lands, through conversion of precipitation to ground water and streamflow, serves the irrigation, power and industrial needs of a vast and rapidly growing empire. Early public support for conservation in this country was based, in part, on the need for safeguarding water supply. Yet in the management of both forest and range lands, water has not been given the consideration its importance justifies.

THE NEGLECT OF WATER resource stems from a number of causes: water is put to use a long way from the catchment basins and it is therefore difficult to show a cash benefit for anything done there in the interest of water. For a long time water users regarded water as a gift of the Gods — free, unchangeable, inexhaustible. Then, too, we have only quite recently recognized the important function of vegetation litter and top soil in the control of water on the land. Even less recently have our educational institutions given much consideration to the problem of controlling water on the land in connection with grazing.

We know now that practices on the range can change total water yield, increase peak discharge of streams, increase rainstorm runoff, pollute streamflow, increase sedimentation, and damage or destroy the soil itself. This paper deals with some aspects of this important problem.

Water Management

Water management on the land is frequently confused with the overall job of *watershed* management of which it is only a part. For example, timber is a watershed resource and timber management is the related functional activity for producing timber and other forest products. Forage plants are a watershed resource, and the recognized functional activity of handling the range for maximum forage production is range management. Likewise, water is a watershed resource — the most important one of all. Its management — where it reaches the watershed as precipitation — among the trees, shrubs and grass must be regarded also as an important functional activity. The integration of these three activities, and others, on a watershed is *watershed management.*

The use by man of water from streams is older than civilization. Beginning with simple use to water flocks and herds, then applying water to the land to grow crops and supply culinary needs, man has finally tied water into a complicated industrial society which depends upon water for generation of electrical energy, for navigation, for a multitude of industrial enterprises, and for culinary use.

As the natural flow of streams became inadequate to supply man's multitudinous needs, rivers and lakes were dammed to regulate flow and increase water available for beneficial use. Water management in streams for irrigation, flood control and electric power generation is now a multi-billion dollar activity. Social and economic developments, huge and complex, have evolved based on these developments.

Another phase of water management — and one that has been long neglected — must be accomplished on the watershed lands where the rain and snow fall. Unless water is controlled on the land, its management in the rivers is doomed to early failure, principally through displacement of reservoir storage capacity by sediment. Above the reservoirs in this country is sufficient soil — potential sediment — to fill them many times. The rate at which they do fill with sediment will depend to a very great extent upon whether rain water enters the soil where it falls, or whether, in flowing over the surface, it carries away part of the soil with it.

The range manager may have a tendency to brush off the idea that the management of water as rain drops must be taken seriously. But does he realize that the average rainstorm releases about 6,000,000 foot-pounds of kinetic energy per acre at the ground surface (1)* and that the bare soil which has for ages been protected by vegetation and litter cannot be subjected to this impact, and to resultant overland flow, and survive? He

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must realize also that the vast amount of water that flows in the rivers below the land he manages appears first as raindrops and snow flakes on the land grazed and trod by his flocks and herds, and perchance turned by his plow.

Consider the enormous amount of water the land converts to soil moisture, to ground water, and to streamflow annually. For convenience of illustration on a watershed where 24 inches of precipitation reaches the ground surface annually:

Acres	Water	
	Tons	Acre-Feet
1	2,725	2
100	272,500	200
10,000	27,250,000	20,000

In a drainage basin the size of the Colorado or Rio Grande the amount of water received and disposed of by the land is astronomical.

Experiments indicate that about 90 to 99 per cent of precipitation infiltrates the soil surface where it is either stored as soil moisture and lost by evapo-transpiration, or seeps through the soil to streams (2) (3). The remainder (ten to one per cent) flows overland to streams. Infiltration is determined largely by surface conditions: Vegetation, litter, loose topsoil favor it, whereas bare compact soil reduces it.

The humid, high elevation mountain lands with precipitation from 21 to 50 inches annually, comprising less than ten per cent of the land area of the western United States, yield the bulk of perennial stream flow mainly because precipitation exceeds losses by evaporation and transpiration. The less humid intermediate elevation mountain lands, which make up about 20 per cent of the area, yield only small amounts of perennial stream flow because they receive only 10 to 20 inches of precipitation annually. The remaining 70 per cent is arid valley land and low mesas with precipitation from five to ten inches annually, most of which is lost by evaporation and transpiration so that practically no water is available for stream flow. Overland flow, however, may be relatively great from these lands.

Overland flow, even in small amounts, erodes the soil and may cause dangerously high stream discharges. For example, the equivalent of 0.1 inch surface runoff from a 10,000-acre drainage basin is about 84 acre-feet and estimated instantaneous peak discharge is about 700 cubic feet per second, which has a great destructive force.

In view of this high potential for rainstorm runoff, the arid range lands are also potential sources of high sediment yield. For the most part such lands, even in their pristine condition, supported barely enough vegetation, litter and top soil to afford reasonable control of water. Too heavy use of plants, and any use at all in delicately balanced situations, releases the great potential for flash runoff and sediment production inherent in them. Great care is needed therefore in management to conserve both the soil and water and prevent disastrous downstream sedimentation.

The Hydrologic Function of the Land

In the disposition of the huge amount of water that falls on the land, every piece of ground — a square foot, an acre, a square mile, a complete drainage basin — performs a vitally important hydrologic function — it receives and disposes of water.

The manner of disposal, whether by seepage through the ground to streams or by overland flow on the surface, is accomplished by several well recognized processes. Vegetation and litter intercept the rain, absorb its great kinetic energy, and transmit the water gently to the soil surface. The condition of the soil surface is the critical point in the control of water by the land for it determines whether infiltration or surface runoff occurs. Water that enters the soil is retained by it until the soil is saturated. This provides a water supply for plant growth. Water in excess of the soil's water-holding capacity percolates through soil and rock mantle to

Figure 1. Gullies in valuable watershed and rangeland on the 10,000 feet high Pahvant Mountains in Central Utah. To prevent such damage to the soil, sufficient vegetation and litter must be retained to control the precipitation water that falls on the land — getting it into the ground so as to prevent damaging overland flow.

rather well established water courses, and through these to the water table or to streams. Thus streamflow is the residual of the precipitation — no water being available for it until the soil is first saturated.

These processes are as "old as the hills." They are the culmination of age-old interaction of precipitation, vegetation, soil and rock mantle, geologic structure, topography and other factors. Throughout the west, soil on many slopes too steep to stand without the support of intermingled roots has infiltrated from 12 to 60 inches of water annually for thousands of years so effectively that soil has not only been preserved — it has been increased in the process. This is a commonplace but most striking phenomenon for it means that over the years (a thousand for example) a column of water as much as a mile high has passed through the soil with little or no disturbance of the soil. Even with root support the soil would be removed if infiltration were impaired.

Change in the Hydrology of the Land

Our libraries are bulging with reports of controlled experiments and careful observations showing that when vegetation, litter or top soil are seriously changed, the hydrology of the land is changed also: (1) surface runoff replaces infiltration and regulated water yield, (2) soil erosion replaces soil development and (3) sediment-laden water replaces clear water.

This vast array of data, collected by state experiment stations and universities, federal research agencies, and private individuals, adds up to one fundamentally important concept: The hydrologic function of the land may be changed and has been changed by man's use. Two cases from widely separated areas will illustrate this.

In west Texas, Ben Osborn of the Soil Conservation Service has just completed a study of water control on gently sloping grass land (4). Under a dense cover of Tabosa grass (*Hilaria mutica*) the soil absorbed 97 per cent of the applied water (two inches in 20 minutes or six inches per hour). The same soil with only an annual weed cover lost 90 per cent of the water as runoff. Osborn's photographs suggest that on the grass plots, even after reserving adequate vegetation to control water, available forage was probably 10 to 20 times that on the weed plots.

On a site in the Wasatch Mountains of Utah, where geologic evidence indicates the soil mantle has been substantially intact for at least 20,000 years, studies of the use of water by plants, and water control on the land were made by Intermountain Forest and Range Experiment Station (2). The results of measurements on 1/10-acre plots from the point of view of water control and soil erosion are as follows:

Cover	Period	Total Precipitation (*inches*)	Surface Runoff (*inches*)	Eroded Soil (*tons/acre*)
Aspen-herbaceous	1936-1946 (11 yrs.)	448	Trace	None
Same area denuded	1947-1952 (6 yrs.)	271	2.9	60.6

These elementary examples drawn from different climatic and topographic conditions illustrate the well known fact that change in vegetation, litter and soil, changes also the way the land disposes of the precipitation that falls on it.

What Happens Downstream

Loss of control of water on the land is destroying at an alarming rate (1) the direct usefulness of water and (2) downstream water management facilities. Let's consider briefly just three cases for purposes of illustration.

On the Wasatch Mountains in Utah impairment of the infiltration capacity through damage to vegetation and litter, on as little as six to ten per cent of six watersheds comprising about 14,000 acres, resulted in flash rainstorm floods which did about $1,000,000 damage in ten years (5). About 1,000 acre-feet of sediment was deposited on valley lands. Impaired drainages produced sediment about 6,000 times faster than unimpaired drainages.

The Sevier Bridge Reservoir in central Utah is an example of reservoir sedimentation. The original 250,000 acre-feet capacity, according to surveys, has been reduced more than 16,000 acre-feet (6). This represents the loss of water supply for one 250-acre farm each year. Sediment is also a serious problem ten miles upstream from the reservoir near the small hamlet of Redmond. The Corps of Engineers recently installed facilities in the Sevier River to keep the channel clear of sediment at a cost of 1⅓ million dollars. Even if the system is effective in protecting the Redmond area from silt damage the silt problem is not solved, because the sediment flushed from the river will cause even more rapid sedimentation of the reservoir.

In the Middle Rio Grande Valley damage by sediment has been so colossal that writers describe it as a "doomed valley" (7). About 437,000 acre-feet of sediment had been deposited in Elephant Butte Dam on the Rio Grande from 1915 to 1947 or about 17 per cent of its original 2.6 million acre-feet capacity (8). Furthermore, it is estimated that 300,000 acre-feet of water is lost annually by evaporation and transpiration of water con-

Figure 2. Sediment from eroded soil on high watershed lands has destroyed (according to surveys) about 16,000 acre-feet of storage capacity in the Sevier Bridge Reservoir in central Utah. Large quantities of water are lost by evaporation during low water stage, from the numerous meandering channels and pools created by the sediment. Water-loving plants such as Salt Cedar have invaded the outer margins of the sediment beds.

suming plants that have invaded the silt beds deposited along the river bed about Elephant Butte. This is enough water to irrigate about 100,000 acres.

At a conference in Albuquerque the shocking truth was expressed by Commissioner of Reclamation Michael W. Straus. He said: "Gentlemen, because of your dire need, I have decided to approve and support the plan and expenditure of approximately one hundred million dollars, but I want to warn you that for this $100,000,000 we are buying approximately 50 years of time unless the destructive land uses of the Rio Grande watershed are changed and improved. Unless your land uses are drastically improved, at the end of such period your reservoirs will be filled with silt and the valley will be again choked with the deposits washed from the uplands into the valley." (9).

Instead of taking corrective measures consistent with the magnitude of the problem, we are being lulled to a painless sleep with such sedatives as: Lake Mead will continue to accept the sediment load of the stream (Colorado River) for 275 years. Glen Canyon Dam can be designed to accommodate the sediment load of the stream for 200 years and yet yield benefits outweighing cost (10). This is indeed an extremely narrow view of the cost of sedimentation. The cost of reservoir sedimentation in the long run will be measured not in the dollars that the sediment pots cost, but in economic and social distress to the dependent people, caused by loss of flood control, power generation and water. *Such costs cannot be measured in dollars.*

Water Must Be Controlled on the Range

In the perpetuation of a civilization based on harnessing streamflow, there is no substitute for the planned control of water in an entire river basin — from raindrops to the sea.

How long will our taxpayers continue to pour billions into water management in our rivers, and billions more for filtering plants and distribution systems, without demanding extension of correlated water management to headlands? To this question there is no specific answer but some very pertinent signs are on the horizon. In many instances where people who have suffered damage by rampaging waters have been close enough to the source of trouble to recognize the cause, they have demanded corrective measures be taken on the watershed lands. In some instances recourse to the courts is provided by law.

In view of the tremendous stakes involved, it is not inconceivable that the people dependent on flood control, hydro-electric power and preservation of reservoir storage capacity for water supply, may some day demand legislation permitting them to take legal action to preserve these vitally important values. The implications of such a course are tremendous and far-reaching.

When streamflow that originates on range and forest lands is decreed to individuals or corporations, they must

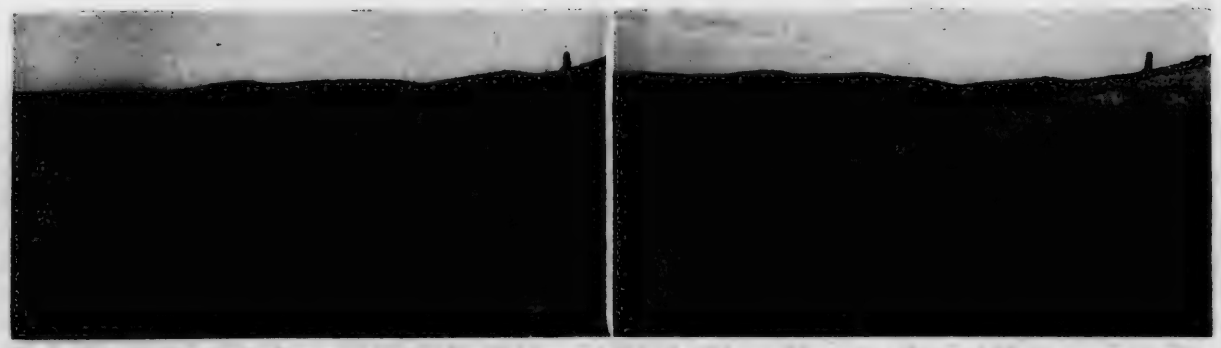

Figure 3. *Left.* On this badly eroded 10,000 feet high watershed in the Pahvant Mountains of central Utah, contour trenches were constructed to regain control of water on the land as a flood prevention measure. This area, in 1946, contributed to a rainstorm flood that caused more than $100,000 damage to a small valley community.
Right. The same watershed two years after contour-trenching and seeding to grasses. The newly established vegetation now puts flash rainfall into the ground and has stabilized the soil. Under careful management, vegetation such as this could provide substantial quantities of forage for livestock and big game, in addition to controlling water on the ground.

fulfil certain specific requirements of the law regarding amount, points of diversion, season of use, etc. Although the decree does not so state, users have a right to expect continuance of the age-old stream regimen and water quality existent under the original decree, and that these will not be altered by any other use.

The people who own watershed land, those who manage publicly-owned land, and those who graze under permit the vast range and watershed land of the West, surely have a tremendous responsibility for the control of water on the lands for which they are accountable.

Range managers are prone to dismiss their responsibility for water management on the lands with the statement that "good range management is good watershed management." This, of course, is a very "iffy" statement. It depends on one's conception of "good range management."

In principle good range management involves two major aspects: *First,* management must be aimed at conserving the thin skin of precious soil on our watershed lands on which both forage production and water control depend. *Second,* all vegetation from current growth beyond that needed to accomplish this is available for use as forage.

This order of objectives is absolutely necessary if we are to preserve our vast range and watershed lands for the benefit of those who use the forage that grows on them, and for those, many miles away, who use the water that is yielded by them.

To accomplish this, the manager must keep his eye on the water that falls among the grass, shrubs and trees from spot to spot, otherwise, he does not have his eye on the ball — so to speak. He must focus his attention on the raindrops that fall on the land and on what happens to them in relation to his management. Technically, this gives him water management responsibility on the land.

Because of the terrific potentiality for destruction inherent in water, the hydrologic function of the land must be regarded as the most important function the land performs. Accordingly, the most important job of the range manager is to preserve that function. If he does not, the soil which is needed to grow grass, shrubs and trees will be lost or impaired, and with it much of the multi-billion dollar downstream water management facilities and dependent civilization. To the users of the grass, shrubs and trees that grow on the land, and the stream flow the land yields, the classic words of Parker Khune are timely: *"We will soon lose that which we do not use well no matter how sure we are that we own it."*

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Science vs. Salt

WELLINGTON BRINK

After ten years the Imperial Valley Drainage Investigation pays off. This is a story of bold and tireless research in a problem area where the stakes are high. It tells, too, of an imaginative application of land-use principles . . . of improved field preparation . . . of water controlled and directed to the equal advantage of an entire farming community. Here is a stirring account of a famous and heroic Valley which might have lost its last great fight for survival had it not been for the resourcefulness of a small but dedicated team of conservation workers. The author offers this report on the Imperial Valley as an example of the fine results being achieved in many parts of the country through the scientific approach.

Wellington Brink

I CROSSED California's famed Imperial Valley in an early spring, in a season of unbelievable bounty, when one hundred twenty-five million silver dollars were flooding in upon the land. Into the Valley flowed this strong tide of new wealth, and out of it by truck and freight car, by boat and plane, moved the Valley produce in exchange: an incredible variety of fruits and vegetables, meats and fibers, and half a hundred other items for the sustenance and comfort of our people.

New wealth lay upon the land and new prosperity marched across the horizons. The season happened to be "right." I saw snow on the brows of distant peaks, and canals in full, sweet flow. The desert flora laughed in wild gaiety.

Imperial's first irrigation canals were chiseled half a century ago. Within their turbid water were joined the blood, sweat, and desperate dedication of a generation of men tough and thorny as mesquite. Those early ditches introduced a long series of convulsive years, when fortunes were easily won and as easily lost, when fields attained fantastic yields and subsequent fantastic failures, when salt was routed only to reappear somewhere else in added concentration. Towns and industries bloomed and withered almost in a day and night, like the short-lived desert flowers at their feet. Problems were beaten, and from their roots sprang up other problems.

It has taken Imperial half a century to find her fourfold formula for success. The Valley long has been blessed with soil, climate, and ditchwater: usually considered an ample dowry. But these advantages were not sufficient here. To them now has been added in the last small pinch of years the most vital requisite of all—*science*. Nowhere else has American agriculture offered a more imperative challenge to science. And nowhere else has science risen more grandly to a farming crisis.

I know you won't believe me when I tell you that the soil—"good" soil—lies a mile or more deep in this hot valley! Not the usual six or ten inches but a full mile or more! Oil prospectors have punched holes down as far as 12,000 feet before striking granite.

But there is no "top soil" at all in the usual sense. Indeed, there is no soil profile. Instead, there is the equivalent of thousands of farms . . . good farms . . . immigrant farms: the intermixed and scrambled soils of seven states—torn away, pulverized, transported and laid down by the madcap Colorado River. These soils traveled from Arizona, New Mexico, Nevada, Colorado, California, and as far away as Wyoming and Utah. They are mostly good, rich, and productive. But they lie grotesquely tangled, layered, compacted, intertwined and confused: gravels, clays, silts, sediments, sands.

Imperial once was a warm, tropical lake. You can still make out an old shoreline high up on the rocks along the entrance to San Gorgonio Pass. And after the inland sea, the Valley became a broad delta when an arm of the Gulf of California reached for the river's discharge and coaxed away some of its muddy burden.

Ton of Salt Per Acre-foot of Water

Salt is the chief enemy. Thinned out and weakened in one area, it has a way of reappearing with renewed

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Figure 1.—Here, at the left, is a necessary prelude to success in the Imperial Valley and other irrigated areas—correct land leveling. This field needs only a little touching up to assure an even distribution of water . . . The high-yielding barley seen at the right is an example of results being obtained in the valley from proper land preparation and scientific management of water.

vigor somewhere else. Because of salt 100,000 acres began going out of production in the second decade of the Valley's opening. After two or three crops, the fields would go bad and farmers would be forced to move to other land. The battle has been constant and interminable. Not only the land is impregnated but the Colorado River itself—the very source of Imperial's irrigation—carries a ton of salt per acre-foot of water. An important part of the struggle has been to keep the salt-content of the soil below the level of tolerance by crops.

Thus is presented no standard situation in irrigation. Experience elsewhere counts little. Hidden beneath Imperial's heated surface are a maze of passages and cross-passages; of aquifiers and aquicludes; of barriers and lenses. The desert's conquest has posed work not only for level and transit and intelligent farmers, but also for soil chemists, hydrological engineers, and mathematicians.

It is only since 1949 that the Valley has been leaching out more salt than it has been bringing in from the River. The painstaking work of soil scientists and engineers is beginning to pay off.

The whole fate of this desert kingdom was at stake when The Imperial Valley Drainage Investigation was undertaken in 1941 on the joint suggestion of a committee representing federal and state agencies, the University of California, and the Imperial Irrigation District. It gave one of agriculture's toughest research assignments to top scientists of the Soil Conservation Service, among them Harry F. Blaney, George D. Clyde, William W. Donnan, Vladimir S. Aronovici, George B. Bradshaw, William W. Fox, Allen C. Bowen, Walter H. von Trebra and their staffs.

Their shops were equipped with test tubes and Bunsen burners and filters. But their real laboratory was the Imperial Irrigation District itself, a district which extends north from the international boundary with Mexico about 45 miles to the Salton Sea and has an average width of about 25 miles.

The research started from scratch. The most fantastic apparatus—some of the machines looking like creations of Rube Goldberg—was devised for determining the permeability of various soils, and for making quick observations of hidden water tables and recording their fluctuations.

New techniques were developed for classifying soils according to their ability to transport water. Soil samples were taken nine feet down or more. Experiments were undertaken to find out what amounts of water would have to be drained away to leach out salt and at the same time maintain a correct water table. Formulas were projected, and tested, for spacing tile drain lines and working them into a field-wide and district-wide drainage system. The lengths of irrigation runs were determined with exactitude. Fertilizer problems were subjected to cold appraisal, and dealt with on an intelligent basis. And the economics of farms involved were studied. Ways had to be found to utilize old systems of irrigation and drainage, and to incorporate them into a new and improved over-all system.

Bill Fox and Researcher Aronovici early in the studies put to work the ambitiously named "variable head multiple manometer discharging permeameter"—quickly dubbed VHMMDP—which was to determine how fast water runs through a soil and at what rate seepage slows down during its progress. This machine soon gave

Figure 2.—Irrigation of row crops has its own technique, but the principle of leveling still holds. Carrots (left) and sugar beets (right) are among Imperial's major crops.

birth to more widely roving offspring convenient for arriving at such determinations under actual field conditions. The knowledge so derived had an extremely practical farming application; it often meant the difference between successful and unsuccessful tile drainage, and between productive and unproductive acres.

One of the discoveries made with the aid of VHM-MDP was the fact that minute stratifications of mica flakes in some sandy valley soils cause water to flow more rapidly horizontally than vertically. Aronovici found that the permeability of soils covered as wide a range as 1,000 to 1, and open soils differed even more than that.

Another innovation was a soil-coring device which delves down in the soil from 9 to 16½ feet and brings up samples of soil layers for classification. This permitted an analysis of the underground make-up of the land, and even its "mapping."

Not only that, but test wells and sumps were established on a grille pattern throughout the Valley.

New Irrigation and Drainage Systems Based on Research

All methods and inventions combined to build up a dependable working knowledge on which drainage and irrigation systems could be predicated. Tile, the investigations disclosed, can lose efficiency greatly if wrongly placed, and can gain greatly in efficiency if laid to take advantage of possible coarser, more permeable layers found in various parcels of Valley land.

The studies were both extensive and intensive. The maps, graphs, analyses, tables, mechanical findings, and mathematical calculations mounted. And while the data accrued, farming operations continued.

As patterns began to appear, their meanings were taken out to the land and put to work immediately. In three years improvements in Valley production began to appear as a direct result. After five years "Operations" took over completely.

Farmers might not be interested in a coefficient of permeability but they were delighted with the lettuce

Figure 3.—Vast ingenuity has been applied to the vexatious problems besetting the rich Imperial Valley. An exact knowledge of underground conditions is peremptory. Here an electrical sounding device has been slipped over the top of a piezometer and a wire with weighted terminal unreeled down the tube. When the terminal touches water it completes a circuit. This is registered by movement of the millimeter needle. A direct reading is made by the position of a foot-mark on the wire in relation to the fixed scale.

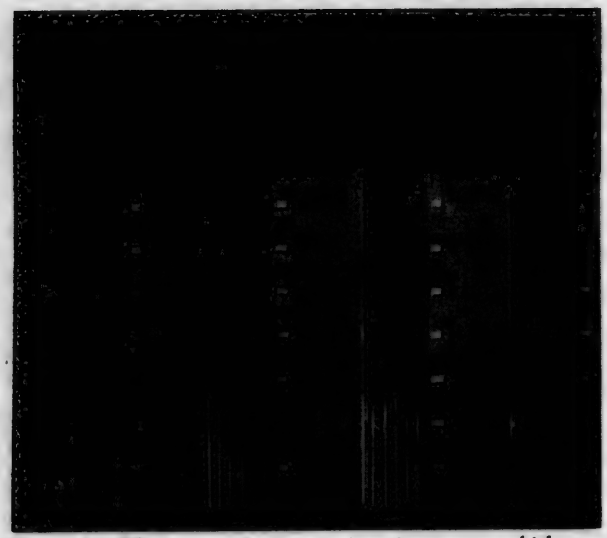

Figure 4.—This manometer is a unique instrument which was developed early in the Valley studies to determine rates of water movement through various soils. The soil samples are in brass tubes behind the board.

crops it helped to make possible. They might not concern themselves greatly with the investigation's extensive grid of piezometers, but they breathed more easily when the Valley showed the first signs of vigorous comeback. In a single recent year more than 10,000 abandoned acres were restored to production.

California now leads in cotton production, a fact for which the Imperial Valley is partly responsible. Two or three bales per acre are commonplace yields in the Valley. Thirty-one thousand acres went into cotton in 1952; 100,000 this year.

More than 603 *miles* of tile drains were laid in 1951. The life of the Valley flows in through 1,830 miles of canals—arteries which are complemented by 1,580 miles of drains.

I saw modern science at work on the old desert. I stood on the ranch of the Korean-American Corporation north of Holtville, in a freshly leveled field that a few weeks earlier had contained hummocks and sand dunes eight feet high. I tried to imagine the desolation of salt brush and mesquite that formerly rioted here on this great quiet, orderly space. I stood beside a giant Santa Ana plow which, after the field was worked to proper smoothness and grade, had turned and mixed and aerated the good soil to a lusty 4-foot depth. In this field the new tile lines were stretched out, unseen, six feet below my feet—already functioning. I tasted the slightly alkaline outflow at the open ditch below; thereby, I was told, I qualified myself as an authentic counterpart of an Alaskan sourdough!

It cost a good $200 per acre for this leveling, plowing and tile system, which might be considered a reasonable investment for the large returns in prospect.

The field, of course, was diked for irrigation. The borders were two feet high, three feet wide at the base, and half a mile long.

Agriculture is Diversified

Here, after leaching, would go barley as an initial test crop. Then, if the test showed adequate leaching, would follow in all probability a crop such as sugar beets, involving larger investment. After this would come a long succession of assured yields, whatever the planting. There are 15 crops in the Imperial Valley which are capable of grossing a million dollars each. And there is a wide variety of lesser but also profitable crops. I even saw in bloom an acre of petunias which brought its grower $8,000 for seed.

Phosphoric acid goes on the alfalfa. All other crops are heavily fertilized with nitrogen.

The water for leaching and reclamation comes free from the Irrigation District. When the farmer gets ready, the district is notified and the field is inspected by the district's agents. The water is turned on at a rate of three acre-feet per day. On a tract of 160 acres it takes about a week for proper flooding. The excess salt starts moving down through the soil to the tile and into the open ditch; the leaching process has begun. It has been found that the faster a field goes salty, the faster it can be cleaned up for crops.

The leaching period extends for 30, 90, or up to 120 days, as required. After 90 days of flow, the water is turned off and the land permitted to dry. Then, if needed, on goes the water again. The grade is slight, the allowable "fall" not being permitted to exceed 3/10 foot between borders, or not more than 1/10 foot to two acres per land. Dikes follow contours, as a rule.

When one of those strong desert winds starts whipping up, there is a mad rush to close valves, for in a matter of minutes such a gale can pile up a 3-foot tide at one end of a field and sweep away the borders.

There's bound to be a certain amount of water wasted in such grand-scale operations, but the waste is held to a minimum.

It was in a season of happy fulfillment that I crossed the vast desert. It was a time of blossoming, when all the land was singing victory for all its generations, when fat grains and sleek herds were telling eloquently of the long and dogged march of pioneering men and pioneering ideas. Here, as in the Columbia Basin and in the old cotton-wearied South, and indeed everywhere in the progress of western civilization, it has been left to the mind of modern man to achieve the ultimate conquest, and to consolidate through science and invention our still rugged and difficult agricultural frontiers.

Hydraulic Tests on Barrel Valves for Use as Irrigation Outlets to Concrete Pipe Lines

VAUGHN E. HANSEN

A UNIQUE IRRIGATION system has been developed by the farmers of Box Elder County in Northern Utah for use on steep, rocky, foothill soils to control the irrigation water at a minimum cost; irrigation of these steep soils will cause excessive erosion unless the water is very carefully controlled. The degree of control developed by the farmers is attested to by the fact that these irrigation systems are used on gravelly soils having a 22 per cent slope without any serious erosion. (Small pebbles in the soil aid in preventing erosion by forming a riprap very soon after the water enters the furrow).

The system consists of a concrete pipe line distributing the water to the field through barrel valves which are grouted directly to the pipe. The valves are connected to the pipe by first punching a hole in the pipe slightly larger than the outside diameter of the intake end of the valve. The valve is then placed into the hole with the intake end of the valve flush with the inside of the pipe. Grout is placed around the valve to hold it in place as shown in figure 2.

Since the valve is grouted directly to the pipe, it is necessary that the pipelines be laid at shallow depths. It is of course possible to connect the valve to a length of steel pipe which is grouted to the concrete line. Such an installation would make it possible to place the pipeline at a deeper depth than was possible when the valve is connected directly to the concrete pipe. However, as yet none of the farmers in the Box Elder area have found it feasible to go to this additional expense.

Two types of shallow installation are common practice. The first type (figure 2) consists of turning the pipe so that the valves are in the side of the pipe with the jet directed downward which soon erodes a small depression in which the energy of the jet is dissipated. This type of installation is preferable, since the energy of the jet which poses a serious erosion problem is effectively and cheaply dissipated. This system is usually used on a distribution line; that is, the line not used to convey the water to a lower field. The valves are individually adjusted so that each valve discharges its proportional amount of the total flow. Usually the valves will be left at their initial setting for succeeding irrigations. Since the farmer's only labor consists of turning the water into the distribution line, the labor of irrigating is reduced to a minimum.

The second type of installation has the valves located on the top of the concrete pipe as shown in figure 1. This system is used when the pipe line serves as a conveyance line to a lower field as well as a distribution line for the adjacent field. When the line is conveying water to another field, the pressures are low enough that water will not flow from the open valves when they are installed in the top of the pipe. Hence, it is not ordinarily necessary to close the valves when conveying water to another field and then to readjust the valves each time the adjacent field is being irrigated. However, with the valves on top of the pipe, erosion from the jet becomes a much more serious problem than when the valves were in the side of the pipe. The jet when the valves are on top of the pipe is broken up by tying a piece of canvas around the valve, by placing a short length of concrete pipe adjacent to the valve, or by a combination of both methods.

The following studies, conducted to supply needed design information, can be considered in two basic parts. The first discusses the maximum operating pressure at which the valves could be used without leakage from the face of the sliding plate. The second part gives the maximum discharge from the valves under various operating pressures.

The valves essentially consist of a sliding plate held

Figure 1. Barrel Valve controlling the flow of water from a concrete pipe line into a furrow. Valve installed on top of pipe.

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Figure 2, *Left*. Barrel Valve to serve as an outlet control is freshly grouted into a piece of concrete pipe. *Right*. Barrel Valve installed near end of concrete pipe line. Jet directed downward.

firmly against the opening by a spring. The larger the valve, the larger is the spring. However, Table 1 summarizing the static pressure and leakage tests indicates that the increased size of the springs in the larger valves is not sufficient to offset the additional area of the sliding plate exposed to pressure. From the table it can be seen that no leaking occurs on the ¾" valve at 25 psi. For the 1¼" valve, no leakage occurs at 19 psi, but for the 1½" and 2" valves, 10 psi is about the maximum pressure that can be applied to the valves without causing the valves to leak. Since most concrete pipe lines are installed for maximum pressures of less than 10 psi, the larger size valves will probably operate satisfactorily without leakage on most concrete pipe systems.

The maximum discharge of these valves under various operating pressures is presented in figure 3 in terms of the main line pressure at the valve location with the valves grouted directly to the concrete pipe. Since the losses which occur at the entrance to the riser, and the losses in the riser and in the valve are all functions of the discharge, the pressure head ordinate of figure 3 is in terms of the main line pressure to make the data more readily usable by the designing engineer. Since the data was collected primarily for design purposes, the discharges are for valves completely open which represents the maximum design discharge.

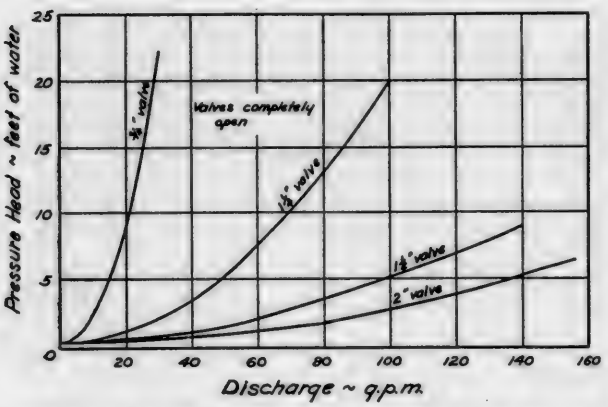


Figure 3. Discharge of barrel valves when installed as irrigation outlets. Pressure head measured at outlet from main line with valve grouted directly to the main line.

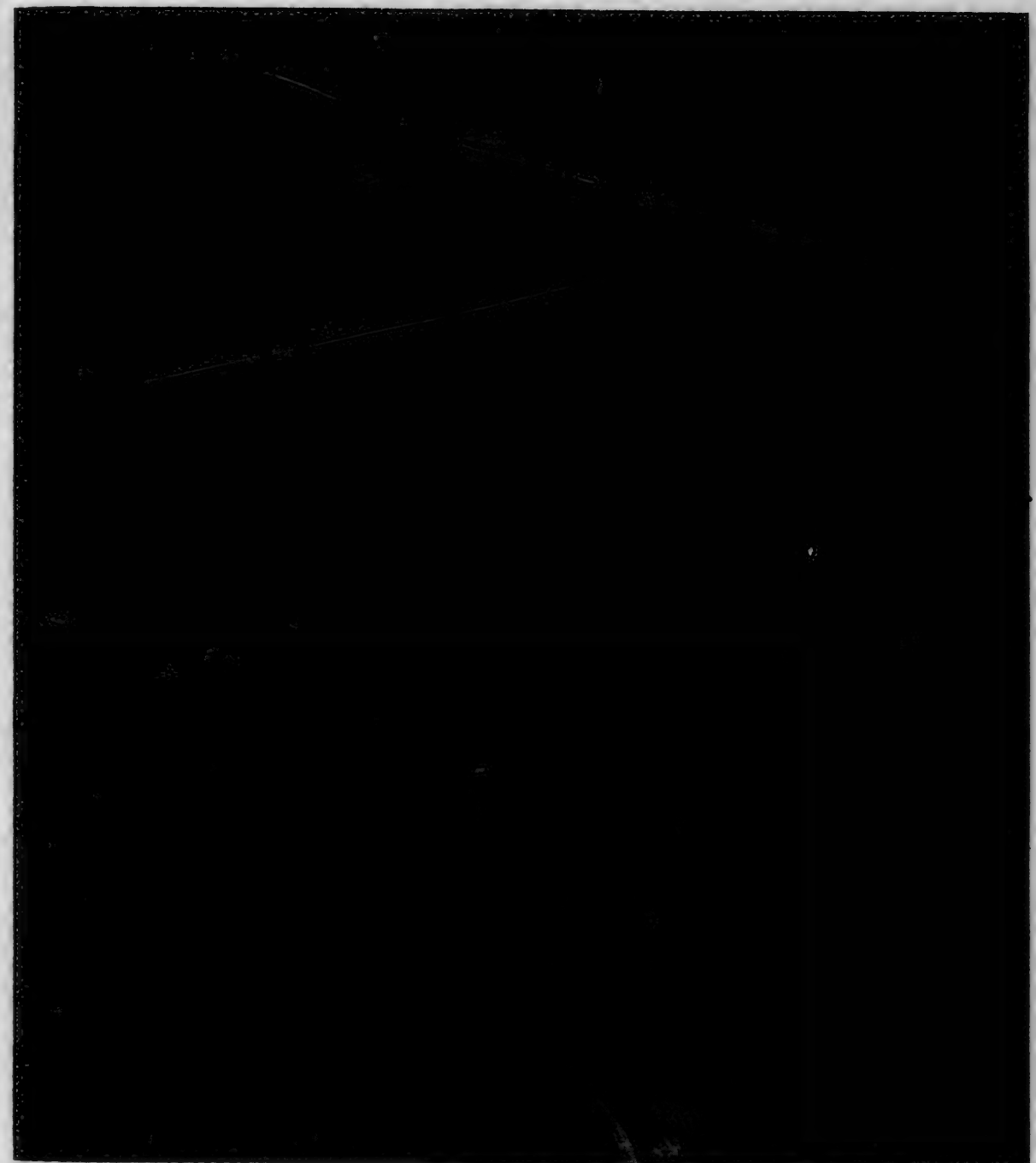
Table 1.—Static Pressure and Leakage Tests for Barrel Valves.

Valve Size (inches)	Pressure in main line (#/sq. in.)	Leakage in g.p.m.
2	9	No leakage
	14	0.01
	19	0.09
	25	0.60
	Started to drip @ 14 psi.	
	Started to run down pipe @ 22 psi.	
	Started to spray @ 23 psi.	
1½	9	No leakage
	14	100 drops per minute
	19	0.005
	25	0.01
1¼	19	No leakage
	25	200 drops per minute
¾	25	No leakage

This system appears to be particularly well suited for use on steep, foothill soils. It is not only economical but also provides good control of the water.

Serious erosion will occur unless positive steps are taken to reduce the kinetic energy of the jet before it strikes the soil.

Table 1 can be used as a guide to indicate the maximum operating pressure for the valves and figure 3 to determine the approximate discharge to be expected from the valves when fully opened for a given main line pressure at the valve location.

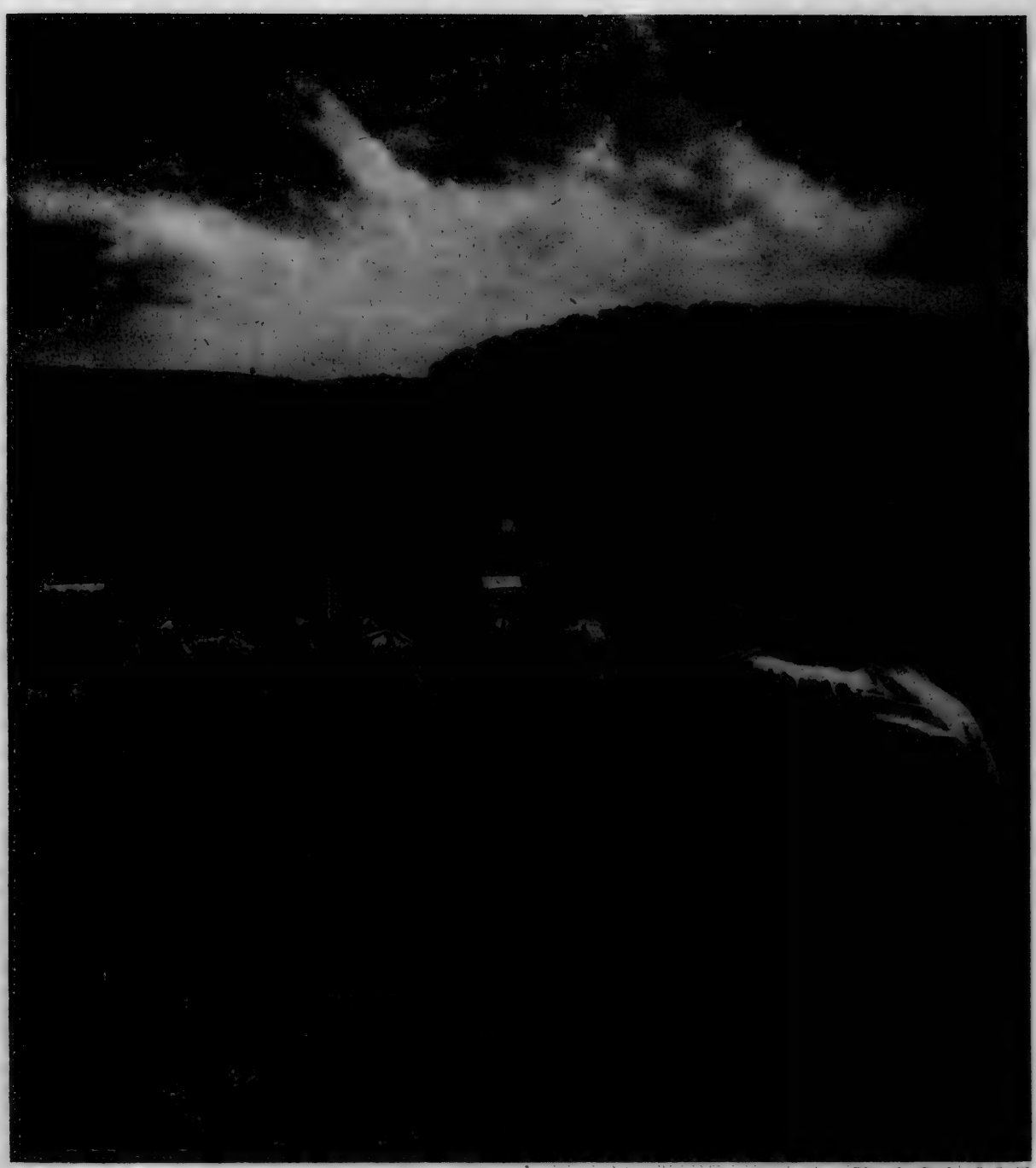


—*Photo by Gordon S. Smith*

This contour vineyard with diversion terraces, outlets, farm road and water supply ponds for irrigation and wildlife is owned and operated by the Taylor Wine Company. The farm is located in Steuben County, New York.

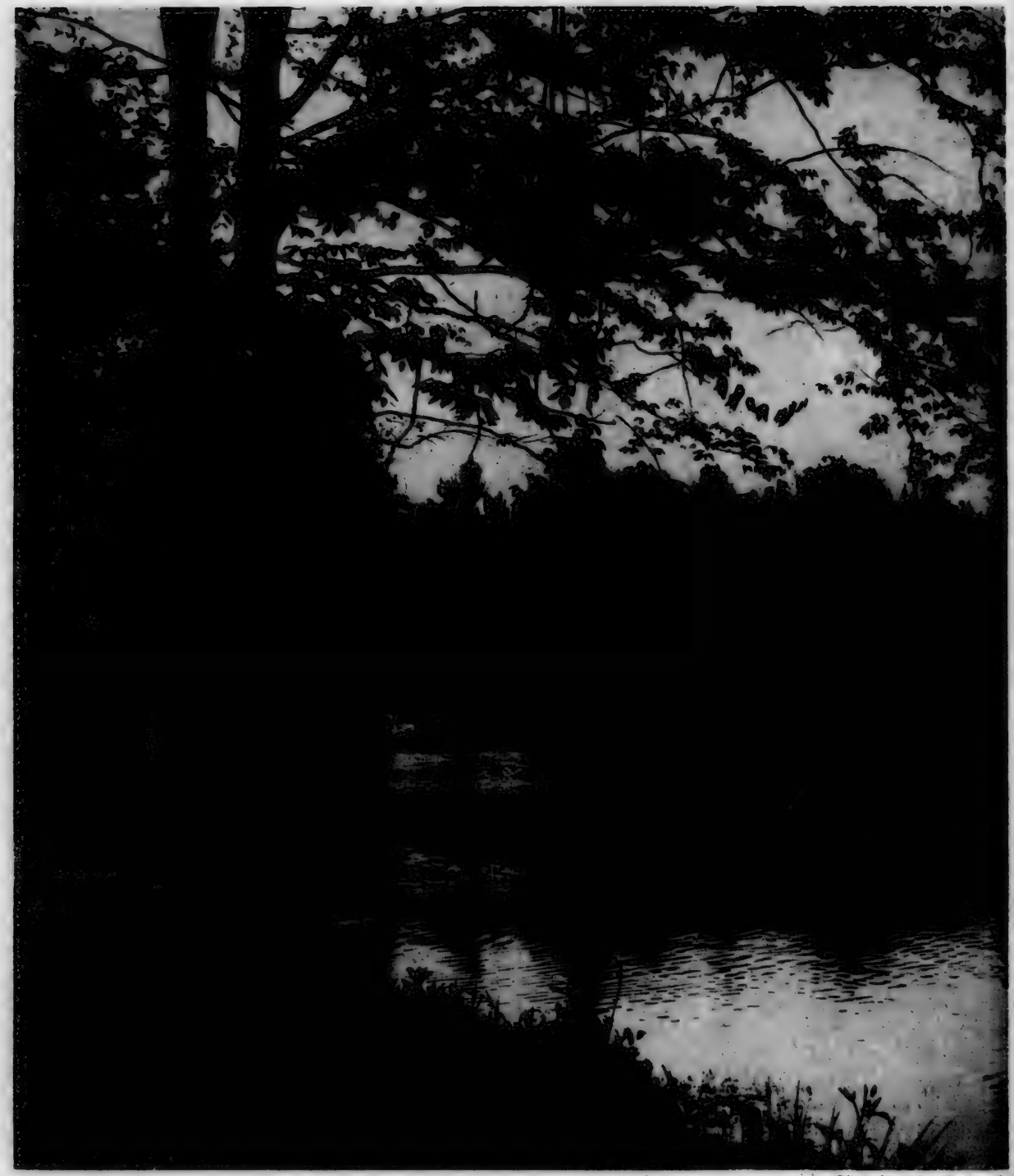
—Photo by Gordon S. Smith

A fine breeding herd of 125 Black Angus cattle grazing on a well managed pasture. The cattle are owned by Stephen W. Duckett, Cambrills, Maryland. Mr. Duckett is a cooperator with the Anne Arundel County Soil Conservation District.



—Photo by Gordon S. Smith

The conservation practices as shown in this photograph are on the Ernest Shook farm near Curllsville, Pennsylvania. The program, based on proper land use, contour strips, pasture management, reforestation and an adequate water disposal system, was established about ten years ago. Mr. Shook is a cooperator with the Clarion County Soil Conservation District.



—Photo by John W. Busch

This three and one-half acre fish pond on the M. D. Griffin farm near Williamston, North Carolina, is well stocked and fertilized. A successful pond site is underlain by soil impervious to water. The watershed draining into the pond should be small and well protected from erosion and excessive runoff.

Gully Erosion Surveying With Aerial Photographs

CHARLES L. GOUFFON

How can the extent of soil erosion and probable control costs be determined accurately and inexpensively? Faced with this problem in collecting information on a 193,000-acre watershed, known to be severely guillied, TVA turned to aerial photographs. Ninety-eight plots of 176 acres each were selected at random and examined under the stereoscope. Data gathered was field checked on eight plots and found to be accurate. Projection of plot data gave information for the entire watershed. Probable control costs were computed from per-acre cost records of past work done in the watershed. Results appear to be accurate; methods used were simple and inexpensive.

MEASUREMENT of the extent of erosion is often an early problem in the development of watershed programs. Following measurement comes the problem of determining probable costs of control measures. As an alternative to field sampling, a time consuming and expensive process at best, the following method based on aerial photograph interpretation was devised. Through its use accurate estimates were prepared at a cost of only one man-day for each 13,000 acres covered.

The area with which we were concerned is the Beech River watershed, a 193,000 acre drainage in west Tennessee. Its soils are loessial and highly erosive. Early accounts of the area contain frequent references to the presence of gully erosion. As early as 1905 the U. S. Bureau of Soils reported: "Numerous erosions occur in all parts of the uplands—some of them 30 to 40 feet in depth . . . almost every rain washes little gullies in the plowed land, and when once started they quickly extend and form deep erosions."

Annual soil loss from the watershed as a whole was recently estimated at 700 tons per square mile—almost 1.5 tons per acre per year. On the upland gullied areas, the loss is 20 times this average, in some cases amounting to almost one surface inch in a five-year period.

At the request of local citizens who are interested in the development of their area, the Tennessee Valley Authority is collecting information on the resources of the watershed. Since erosion is one of the major obstacles to watershed development in the Beech River area, an erosion survey was one of the first tasks undertaken. This survey was made by stereoscopic examination of aerial photos, a method proved quite accurate by subsequent field checking. While we would have preferred more recent photography, five-year-old photos were available and we used these.

Sample plots were selected on a map having a scale of one inch to the mile. We first delineated the bottom land of the Beech River and its principal tributaries. These areas have no gully erosion so no examination was necessary. This cut the total watershed area by about 13 per cent. We next drew grid lines on the map at intervals of 2 minutes and 30 seconds, both horizontally and vertically. This interval was purely a matter of convenience. Any uniform interval of one-half to one inch would have been equally satisfactory. Then 98 of the grid line intersections were selected at random as centers of sample plots. Intersections falling in the bottomland portion were eliminated and others chosen in their place. Plot centers were then transferred to the aerial photos.

To facilitate photo interpretation, we used a transparent plastic grid divided into 16 square units to delineate the sample plots. Each unit measured 0.22 inch on the side. We calculated this to be equivalent to ten acres at a scale of 1:36,000. However, the actual scale of the photos, checked at 37 different locations throughout the watershed, was found to average 1:37,700. This meant that each grid unit contained 11 acres and that the sample plot area was 176 acres instead of 160 as originally planned. Sample plot area was ten per cent of the total upland area of the watershed.

The following information was recorded for each sample plot: area of woods, areas of severe and moderate gully erosion, and total number of gullies. We defined areas of severe gully erosion as those that would require

Figure 2. This veterans training class in Beech River watershed is learning how to control erosion by doing the job.

Charles L. Gouffon is assistant chief, Forest Development Branch, Division of Forestry Relations for The Tennessee Valley Authority.

Figure 1. This is a typical aerial view of Beech River watershed. Note severe erosion in center foreground.

extensive brush and wire check-dam construction prior to tree planting. Moderate erosion areas were those where only light check-dam construction must precede planting for early control. Gullied or sheet-eroded areas requiring no preparation before planting were not included in the survey.

The two persons who made this aerial photo survey are experienced erosion control technicians, thoroughly familiar with field conditions in the Beech River watershed. We believe that such experience is quite necessary in a survey of this type. As a check on the uniformity of their observations, the two men each examined the first ten plots independently. Comparison of findings indicated almost complete agreement in results.

Field checking of eight widely scattered sample plots showed that the information taken from the photos was highly accurate in terms of what was actually on the ground. All data were then projected for the entire upland portion of the watershed.

Now that we had information on the extent and severity of gully erosion, we needed estimates on the cost of erosion control work. Basic to these estimates we assumed—

1. That permanent erosion control would be attained through the establishment of vegetation —principally trees.
2. That in order to assume prompt control, tree planting would be preceded by construction of simple erosion control devices—brush and wire check dams, mulching, brush paving, etc.
3. That landowners would construct erosion control structures on their land and furnish their own materials, that they would also plant the trees.
4. That technical supervision and guidance would be made available to landowners by public agencies.

Since numerous successful erosion control projects had been established in the area by landowners, by CCC labor, and by force account labor, control techniques were well developed. This type of simple land treatment, for example, has reduced annual soil loss from 13,000 tons per square mile to about five per cent of that amount on a 90-acre experimental area in this watershed. From records on these earlier projects, we selected five at random that would meet our definition as containing severe erosion. On these we counted the average number of erosion control structures per acre. We made a similar determination for moderately eroded areas. Accurate construction costs in man-days for the various type structures were then computed. From these averages, we determined total construction and man-day needs for the watershed.

The survey showed that the upland portion of the watershed (168,000 acres out of the total of 193,000 acres) contained some 3,900 acres of severe erosion and 7,700 acres of moderate erosion. The number of gullies on this area was estimated at 90,000. As for control, our estimates indicate it will require over 250,000 brush and wire check dams, plus considerable amounts of mulching, brush paving, gully rimming, etc. Labor requirements will be in the neighborhood of 130,000 man-days. In addition to this preparatory phase of the job, the reforestation phase will require 18 million seedlings and 25,000 man-days of labor.

Where aerial photos are available, this type of erosion survey is recommended. It is accurate, simple, quick, and inexpensive.

From Land Exhaustion to Soil Conservation

PAUL TABOR

A century ago Edmund Ruffin and Daniel Lee presented eloquent arguments against land exhaustion in the United States and especially the South. Most farmers of that time continued their "land killing" practices. Progress came with the introduction of more soil protecting crops, the increased use of commercial fertilizers and lime, and improved techniques of soil protection. The repeated observations of enormous damage from soil erosion of cultivated lands led to the statement of a national policy of farm land protection in 1907. Much progress toward the accomplishment of this policy has been made during the past 20 years.

SOIL CONSERVATION is both a relatively new and an old subject. As the Southern Agricultural Workers recognize the half century of their organization, the writer proposes to go back another half century and review the thinking about soil conservation as revealed in the available agricultural literature.

Some of the farm leaders a century ago were much concerned with soil exhaustion. The agricultural volume, Report of U. S. Commissioner of Patents-1852, reflects their anxiety. The following is from this publication:

"Twice the quantity of rain falls in the Southern States in the course of a year that falls in England, and it falls in one-third the time. It is not so much the atoms removed in crops as those washed out in solution, or suspended in water as fine mud, that impoverishes the arated fields of the planting states."

"*. . . it is painful to contemplate the fact that we so misapply our physical and intellectual energies as needlessly to impoverish the land in every State and Territory of the Republic.*" "*We have a continent for the basis of agricultural operations, embracing climates and physiological and material resources, equal to the want of a thousand millions of prosperous and happy people.*"

". . . Cotton has destroyed more land than earthquakes, eruptions of burning volcanic mountains, or anything else. Witness the red hills of Georgia and South Carolina that have produced cotton till the last dying gasp of the soil forbids any further attempt at cultivation and the land turned out to nature reminding the traveller as he views the dilapidated country, of the ruins of Greece." . . . "I was raised in a hilly country of the Old World, but I never saw these hillside fields . . . so badly washed as they are here . . . in one single year. Some of our hill places are already ruined beyond redemption . . . and this is a new country. Farming in the old style will do no longer; . . . we are bound . . . to put more of our land in clover and grass . . ." "The frequent turning and loosening of the earth, by the plough and hoe . . . and far more when continued, without intermission, year after year . . . advance the decomposition and waste all organic matter, and expose the soil of all but the most level surfaces to destructive washing by rains . . . and rains the more heavy and destructive in power in proportion as approaching the South." . . . "There is not one of the industrial classes of mankind more estimable for private worth and social virtue than the landholders and cultivators of the Southern States . . . Honorable, highminded, kindly in feeling and action, both to neighbors and to strangers, ready to sacrifice self interest for the public weal . . . such are the ordinary qualities and characteristics of southern planters. Most of the intelligent men of this generally intelligent class are ready enough to accept and to apply to themselves and their fellow-planters the name of 'land killers'. They have regarded their 'land-killing' policy and practice merely as affecting their own personal individual interests; . . ." ". . . But with the impoverishment of its soil, a country, a people, must necessarily and equally be impoverished." . . . "And these evils to the community and to posterity, greater than could be effected by the most powerful and malignant foreign enemies of any country, are the regular and deliberate work of benevolent and intelligent men, of worthy citizens and true lovers of the country."

In the writer's opinion, these statements mark the approximate end of an era of thinking about soil conservation. The leader, Edmund Ruffin, in 1853 was becoming old and disappointed and involved more and more in the tense politics of that time. His thinking and practicing of soil conservation on his own farm did not coincide with the commonly accepted methods of exhaustive culture (15). His long-term economic concepts were overwhelmed by the short-term practices of continuous careless cultivation, abandonment of worn-out fields and clearing of new land. As this era passed, soil conservation thinking split up into specialized lines. The problem as a whole was not generally discussed in agricultural literature applicable to the South. A few publications like USDA Farmers Bulletin 20, Washed Soils: How to Prevent and Reclaim Them (1894), indicate some interest.

Paul Tabor, a member of the SCSA, is management agronomist for the Soil Conservation Service. His headquarters are at Spartanburg, S. C. Mr. Tabor presented this paper before the Soil Conservation Section of the Southern Agricultural Workers Conference at New Orleans, Louisiana, February 11, 1953.

The tests by Kefauver (7) of the Tennessee Experiment Station on reclaiming washed lands indicate an interest by the recently organized state experiment stations.

As the present half century began in 1903, the interest in preserving and improving the soil must have increased. The USDA Yearbook of that year discussed the relation of soil porosity and granulation to washing of soils and the use of deeper plowing and terraces to prevent it. Two years later in the USDA Yearbook of 1905, the desirability of as little cultivation as possible during the fall and winter was observed for soils subject to washing. The next year USDA Farmers Bulletin 245, Soil Conservation, was published and reissued four years later. Apparently by 1907, a clearly defined desirable national policy had been outlined in the U. S. Department of Agriculture. The Secretary of Agriculture gave the following in his Report of 1907.

"*Another line of work in the Bureau [of soils] relates to soil erosion. According to the latest determinations (beginning with the classic measurements of the Mississippi by Humphreys & Abbott), the rivers of the mainland United States are annually pouring into the seas* 1,000,000,000 *tons of sediment. . . The volume of material thus lost to the land is increasing with settlement and cultivation: it is almost wholly washed from the surface and is the very richest soil material, the cream of the soil. The value of the material is not easily fixed, but at a moderate appraisal the annual loss would exceed all the land taxes of the country. . .*

"Erosion is due directly to the runoff of water of which the ratio is dependent partly on slope, but chiefly on the nature of the soil and its produce; indeed, with any reasonable slope, a full cover of forest or grass with an abundant mulch, or a close crop on deeply broken soil, or a friable furrow slice kept loose by suitable cultivation, will so fully absorb precipitation as to curtail the runoff or even to reduce it to slow seepage through the surface soil . . . the ideal condition, and the one toward which modern agriculture should be bent. . .

"The immediate source of our prosperity is the soil of the American farm and it is a national duty to see that the soil is conserved and the farm improved for the immediate benefit of the farmer and ultimate welfare of the country. One of the richest assets of the nation is the water that falls on the farms, permeates the soil, permits organic growth and after enriching the land, flows seaward through the commonwealth to furnish substance and power and afford means of commerce; and it is coming to be recognized as one important duty of the nation to see that this water shall be so controlled and conserved as to yield the greatest benefits to the holders of the land on which it gathers and eventually to all the people. At the same time, the evils of soil erosion begin on the farm and, while they extend thence to the pollution of the streams of the states and the obstructions of interstate rivers, it is becoming clear that the remedy must begin with the farm and it is a national duty to see that the remedy is prescribed and applied."

This thinking of the soil conservation problem as a whole, with a shift to recognize the public's stake in conservation use and treatment of land, was not accepted by the U. S. Congress for about a quarter of a century. H. H. Bennett persisted more than any one else in advocating the new ideas. During the mid 1930's, soil conservation was adopted as a national policy. Its progressive development from that time until the present is well known to the older group of Southern Agricultural Workers. A large amount of literature describing it is available for the younger group.

Progress in Specialized Phases of Soil Construction

Much of the modern thinking about soil conservation is due to progress made in specialized fields after 1853. One important field was commercial fertilizers. Edmund Ruffin and other early Southern soil conservationists advocated the use of farm manure and composts with lime and a legume in the rotation. This combination of practices, essentially from Great Britain and Europe, was generally inadequate to maintain soil fertility in the South. The shift from manure to commercial fertilizer as the source of additional elements required by plants has been progressing steadily for 100 years.

Two of the early leaders were Thomas G. Clemson (3) of Maryland and South Carolina and Dr. Daniel Lee (2, 3) of New England and Georgia. These men, trained in chemistry, developed both the theoretical and practical aspects of the problem prior to 1861. David Dixon (2) of Georgia developed the practical plan of using adequate amounts for high yields of cotton both before and after the Civil War. Eventually, heavy use of commercial fertilizers was transferred to soil conserving crops. Edmund M. Pendleton (12) of Georgia was active during the 1870's in developing commercial fertilizer companies and in suggesting the quantities of commercial fertilizer most profitable for different crops. Numerous farmers throughout the South conducted tests to determine the maximum amounts of commercial fertilizer that could be used profitably. H. W. Ravenel (13) of South Carolina produced 10 tons of Bermuda grass hay per acre by using nitrate of soda.

Near the end of the first half century under consideration, the state experiment stations were organized and became active in experimenting with commercial ferti-

lizers. During the second half century, this branch of research was expanded greatly.

Another specialized field was soil conserving forage crops in the Cotton Belt. Bermuda and Johnson grass and the cowpea were the principal domesticated kinds 100 years ago. Annual lespedeza had been accidentally introduced but had not spread much nor had it been identified. After the Civil War, H. W. Ravenel (14) learned its identity through Dr. Asa Gray, and saved the first seed. Its value for soil conservation was recognised but successful use of it as a cultivated crop awaited the efforts of J. B. McGehee of Laurel Hill, La., during the 1880's. Thomas Affleck (1) of Mississippi and Texas during the 1850's advocated introduction of better grasses from the warm parts of the world. Dallis grass was brought in apparently by accident prior to 1875 but received its name from Abner T. Dallis of LaGrange, Ga., where a packet of seed from Australia was received during the 1890's. David L. Phares (13) of Mississippi published "The Farmers Book of Grasses and Other Forage Plants" in 1881. He discussed tall fescue and advised it for pasture mixtures on wet soil. C. W. Howard (6) of Georgia advocated grassland farming before and after the Civil War. B. V. Iverson of Georgia promoted rescue grass. During the mid 1890's, Gerald McCarthy (9) of the North Carolina Agricultural Experiment Station at Raleigh, N. C., was testing various fescue grasses, orchard grass, blue grasses, common lespedeza, sericea lespedeza, bicolor lespedeza, and very probably Korean lespedeza and Ladino clover as well as other grasses and legumes. During the second half century under consideration, a few additional superior species were introduced, i.e., Bahia, Pangola and various bluestem grasses, Kobe and present day strains of Korean and sericea lespedezas. Some superior varieties have been produced by plant breeding, i.e., Tennessee 76 lespedeza, anthracnose-resistant red clovers, Atlantic alfalfa, Coastal and Suwanee Bermuda grasses, and Climax and Rowan lespedezas.

A third field of partial soil conservation was soil manipulation to prevent uncontrolled rainfall runoff and associated erosion. Deeper plowing, contour tillage, hillside ditches and terracing were advocated more than 100 years ago. They were practiced by some farmers. Broadbase terraces with a slope for drainage and grassed outlets were described on a Virginia farm in 1838 (17).

Dr. N. T. Sorsby (16) of Hinds County, Miss., wrote a prize essay on Horizontal Plowing and Hillside Ditching in 1857. He cited work of this type done on his father-in-law's plantation. In 1858, Garland D. Harmon, an enterprising overseer of western Georgia, was employed by Dr. M. W. Philips of Hinds County, Miss., and claimed to have run the first terraces in that county. Harmon had learned of terracing from the earlier work of Richard S. Hardwick of Hancock County, Ga. (2). During the 1880's, P. H. Mangum of Wake Forest, N. C., developed a broadbase terrace widely accepted in that state.

Many other farmers in the South made contributions to the art of terracing. A field study of terracing in the South was begun by C. E. Ramser of the U. S. Department of Agriculture in 1915 and the most successful practices were described in Farmers Bulletin 997. An improvement in terrace channel design resulted in the Nichol's terrace described in Farmers Bulletin 1790. Refinements have since been made in terrace placement and use of all natural drainage ways as outlets.

The need of more than terracing for good soil conservation has been recognized for a long time. It was clearly stated by Massey (10) in 1907. Crop rotation, deep plowing and use of cowpeas in corn were advocated more than a century ago. The dependence on terracing as the main erosion control measure persisted in the South until recent years. Moorhouse (11) discussed control measures without terracing for Oklahoma in 1910.

The literature of soil exhaustion, soil washing, soil conservation, and soil reclaiming was not extensive between 1853 and 1930. It has been voluminous since. Of the 4,388 titles in Bibliography of Soil Erosion and Soil and Water Conservation in 1938 (5), many more than half the total were published after 1930. The authors were geologists, geographers, engineers, foresters, soil scientists, agronomists, horticulturists, entomologists, farmers, and editors.

Two ideas have been found that could be explored more adequately in the future. The first is the relative gain from windborne dust from drier regions to the West. Keyes (8) estimated this gain in the Mississippi Valley Region to be greater than losses from water erosion. The second idea is increased vulnerability of most soil conserving practices at critical moisture relations. Forests may induce landslides during excessive rainy periods. (4) Massey (10) states terraces and row ridges are worse than no treatment when a flood overtops and breaks them. Several farmers have reported similar views to the writer. Some have been bitterly disappointed with deep plowing on slopes of 10 to 15 per cent.

The thinking concerning soil conservation has changed much during the past century. Three ideas have grown during this period. The first is the need for soil conservation. This was accepted fully by a very few 100 years ago. In recent years, it is accepted by the majority of citizens. The second idea is the fundamental causes

(*Continued on page* 184)

Continuous Organic Matter Supply— The Key to Soil Aggregation and Biological Activity

J. H. STALLINGS

Organic matter serves as food and energy for soil microorganisms and is the source of the cementing substances which bind soil grains into aggregates. Soil microorganisms acting on fresh organic matter produce or synthesize these cementing substances. These cementing substances are subject to destruction by other soil microorganisms, consequently they are transitory in effect. A continuous supply of fresh organic matter must be available to provide replacement of these cementing substances as they are destroyed or aggregation of the soil deteriorates. Organic matter is more effective as an aggregating agent when fresh, and when utilized on the surface of the ground than when turned under. Those cropping systems and other soil and crop management practices which disrupt the surface supply of organic materials affect soil aggregation adversely.

THE PLANT RESIDUE on forest floors, meadows, pastures, and other undisturbed areas is a most effective device of Nature for maintaining healthy, productive soils. The surface organic materials, through leaching by rain and snow melt, supply substances essential to the formation of soil aggregates. They also provide food for the myriad of soil microorganisms.

Certain of the products produced or synthesized by soil microorganisms, as they break down the organic matter, serve as cements to bind the soil grains into aggregates. These aggregates impart to the soil the tilth favorable to the growth of cultivated plants and high crop production.

These cementing substances are temporary in effect. They are destroyed by other soil organisms. Soil aggregation persists only as long as the cements are capable of holding the soil grains together. Continuous replacement of the aggregating substances then, is essential to permanent aggregation.

Surface accumulation of plant residues is Nature's means of providing the soil with a continuous supply of cements for aggregation. Surface accumulations are constantly being replenished with material in the form of falling leaves, twigs and other above ground parts of higher plants. Fresh supplies are leached out and carried into the ground with each rain and snow melt.

This litter and other organic residues are generally more effective in soil aggregation when utilized as surface covering than when incorporated into the soil. They exert maximum influence when kept in continuous supply. Those management practices which disrupt normal contributions to the soil from fresh organic residues, even for short intervals, have an adverse effect on soil aggregation and the balance in the soil microflora.

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Humates and Soil Aggregation

The humate fraction of organic colloids produced in the course of the decomposition of fresh organic matter by microorganisms appears to be the most important factor contributing to the formation of soil aggregates (33). The portion of the organic matter which forms these materials is soluble in water, and easily leached out of the fresh organic matter by rain and snow melt and carried into the ground. When the material enters the soil, it serves as food and a source of energy for the microorganisms which produce the humates. The aggregating effect of these materials is only temporary. It rises rapidly from the time they enter the soil and reaches a peak within 20 to 30 days (7). After this its effectiveness declines steadily, causing the aggregate structure of the soil to deteriorate unless additional supplies of fresh organic materials are applied.

Other microorganisms destroy these cementing or aggregating substances (17). Thus, in order to maintain a high aggregate soil structure, a continuous supply of organic matter must be present to keep feeding this material into the soil by way of leachings. This can be done only where the surface of the ground is kept covered with litter, which is replenished frequently to provide a fresh supply to the soil each time it rains (Figure 1).

It is the soluble portion of the organic matter and not its mere physical presence that is responsible for the formation of soil aggregates (15). The practice of incorporating organic matter into the soil makes large amounts available for short periods but does not provide continuous supplies. It follows, then, that incorporating organic matter into the soil is not as effective as leaving it on the surface of the ground where it can be replenished in maintaining a high level of aggregation (12).

Those organic substances which are most easily de-

composed, and which support a maximum of biological activity, are the most effective in producing and maintaining a high state of aggregation in the soil (12). Likewise, the level of aggregation is closely related to the rise and fall of the organic matter supply, and in turn the number of microorganisms present. Improved soil structure remains only as long as the decomposition products exist.

The effect of this process on soil aggregation may be observed by comparing virgin soil with similar soil which has been in cultivation for a number of years. The virgin soil, or that found under continuous sod, or on a forest floor, will be mellow and easily stirred (Figure 2). If a handful of it is spilled through the fingers, it will have a grainy, crumb-like texture. Those tiny particles—the aggregates or "little clods"— play an important part in crop production.

By way of contrast, the soil in a bare, cultivated field will be firm and hard. It won't have any crumb-like structure. When it is plowed, the "clods" will be large and lumpy (Figure 3).

The difference in these two soils is due mainly to soil aggregation. These "little clods," the particles that run through the fingers, are soils that have had a continuous supply of organic matter, such as meadows or forest land. They will have good structure, lots of aggregates (Figure 4), whereas cultivated soils or soils inadequately supplied with organic matter may have very little or none at all.

The organic matter responsible for this structure also serves as food for the vast hordes of microorganisms in the soil. These organisms, in addition to playing an active part in the production of soil aggregates, are instrumental in maintaining a healthy condition in the soil. The complex microflora of a given soil is Nature's means of maintaining a sanitary condition in the soil (35). Certain soil microorganisms, in addition to reducing organic matter to humates, also produce antibiotics which are capable of destroying germs that cause specific plant diseases and viruses as well as controlling some insect pests.

Organic Matter and Soil Aggregation

The aggregate condition of a soil is determined by both the amount and quality of the supply of decomposition products or organic matter present (6, 13, 20, 22, 24, 25, 26, 27). If the supply of organic matter is ample, as in continuous sod, the soil will be in a high state of aggregation. On the other hand, if the supply of organic matter is inadequate, as in the case of clean tilled crops, there may be little or no aggregation in the soil. This is illustrated in part by Table 1 which shows the effect of the rate of application of different organic materials on the percentage of aggregates exceeding 0.25 mm. in diameter (6).

Table 1.—The effect of the rate of application of different organic materials on the percentage of aggregates exceeding 0.25 mm. in diameter.

Organic Matter	Rate of application in tons per acre					
	None	1	2	4	6	8
Wheat straw	37.6	38.4	41.0	44.0	46.1	49.4
Rye and vetch	37.6	38.4	41.8	47.0	51.2	56.6
Alfalfa	37.6	39.3	42.0	48.5	54.2	60.0
Sucrose	37.6	44.0	48.9	61.0	70.5	75.5

The figures in Table 1 show that both the quality and kind of organic matter affect the aggregate structure of the soil. The percentage of aggregates exceeding 0.25 mm. in diameter increased with each of the four organic materials used in ratio to the amount applied. The quality of the organic matter was even more important than the quantity as shown by the contrast between the effects of wheat straw and alfalfa and sucrose. One ton of wheat straw or of rye and vetch increased the aggregation only by 0.8 per cent compared with the untreated soil, whereas the increase due to alfalfa was 1.7 per cent and that from sucrose was 6.4 per cent. The increase for alfalfa was more than twice that for wheat straw or rye and vetch and that for sucrose was eight times as great. These effects continued with the 2-, 4-, 6-, and 8-ton rates of application but in different degrees.

Figure 1. The bluegrass sod on the strip between the pavement and fence provides a continuous cover of grass and litter. The corn in the field to the right provides plant cover only for the period the corn occupies the land. During most of this period the corn is growing and does not provide dead plant material for aggregation.

Figure 2. This is a sample of virgin soil from an area in sod. The soil is well aggregated. It has good structure and excellent tilth.

The degree of aggregation in soil is also influenced by those factors which determine the rate of microbial activity (15, 31). The more rapid the rate of decomposition, the higher the state of aggregation. This means that before organic matter is effective as an aggregating agent, it must be decomposed (15).

Since different crops produce different amounts as well as qualities of organic matter, a wide variation is to be expected in the aggregating effect of the residues produced by various crops (18, 20). For example, alfalfa (13) or clover (19) residues are more effective in producing aggregates than wheat or grass. This difference persists even though the alfalfa and wheat straw residues are ground into a fine powder before being added to the soil. Oats following corn were more effective in maintaining aggregate structure than sorghum.

Those practices which increase the amount of organic matter produced favor improved aggregation. For example, soil limed and planted to clover was more highly aggregated than similar soil planted to clover without adding lime (19). Likewise, those cropping practices or systems which provide a continuous supply of organic matter favor total aggregation and the formation of a high percentage of large aggregates (12, 34). This is borne out by the fact that mulched wheat and bluegrass plots in Ohio were more highly aggregated than corn and soybean plots. Corn was especially destructive to soil aggregate stability on land which had been in hay the previous year (34). Aggregation on continuous bluegrass sod and on mulched orchard land was highest of all in both total aggregation and per cent of large aggregates (12). Aggregation of soil devoted to second year timothy was less than similar soil devoted to continuous bluegrass sod. The correlation between organic matter supply and soil aggregation is high (34).

The importance of the quality of organic matter and its rate of decomposition as measured in terms of microbial population on soil aggregation may be illustrated further by comparing sucrose with more slowly decomposable materials. The addition of sucrose to soil in South Carolina caused a marked increase in microbial activity and soil aggregation (26). Bacterial numbers increased rapidly following the sucrose treatments, reaching a peak in about four days. They then decreased rapidly to approximately four times the number in the untreated soil at the end of 24 days. At the end of four months there were only about twice as many bacteria in the treated as in the untreated soil. The percentage of large aggregates increased rapidly following the sucrose treatments and coincided approximately with the large increase in numbers of bacteria, although the improved aggregation persisted long after the bacterial population declined (24, 26). Aggregation was not affected when sucrose was added to a sterile soil which was kept free of microorganisms (24).

Aggregation was increased in a soil inoculated with bacteria and fungi following the addition of sucrose and ground straw over similar soil receiving the sucrose and ground straw but not the bacteria and fungi (25). Inoculated soils to which neither oat straw nor alfalfa was added underwent only slight to moderate degree of aggregation whereas a similar soil to which oat straw and alfalfa had been added had a considerable increase in aggregation (9).

The higher the percentage of readily decomposable constituents in the organic matter, the greater is its effect on soil aggregation (16). Composted organic matter, in addition to losing some of its aggregating effect, requires a longer period to attain its maximum effect, whereas fresh straw mulch is an active aggregating agent (38). It is particularly effective in producing large aggregates. The kind of crop or organic matter is more important to aggregation than the organic carbon, nitrogen, carbon-nitrogen ratio, or lime (1).

Organic materials that decompose rapidly increase aggregation within a few days, have their maximum effect in about 20 to 30 days, and then gradually lose their effectiveness (7). Materials which are slower to decompose require more time to exert their binding effect but are effective over a longer period. Relatively inert materials have little, if any, effect upon aggregation.

Decomposing organic matter concentrates in and

around soil aggregates. As a result well aggregated material has a relatively higher carbon and total nitrogen content than unaggregated soils (13, 19, 20). They also possess a higher content of slowly oxidizable organic carbon and a wider carbon-nitrogen ratio than poorly aggregated material.

Cropping Systems and Aggregation

Cultivation and other practices which influence the continuity and organic matter content of the soil affect both aggregation and crop production. This also applies to those practices which eliminate or reduce the plant cover to the point where it is no longer effective in protecting the soil against the damaging action of falling raindrops or freezing and thawing (4, 21). As soon as land is taken out of sod and cultivated, the soil starts to deteriorate physically. For example, in Iowa, cultivation reduced the aggregation of Albia soil 88 per cent and Weller soil 65 per cent (30). However aggregation in soils supplied with sucrose, cornstalks, and alfalfa increased 720, 335, and 335 per cent, respectively, within 30 days. These organic substances were added at the rate of 50 tons of dry matter per acre. Samples taken 84 and 168 days after the organic matter was added showed that the soils were again losing their structure. An application of eight tons of manure per acre showed little effect on soil aggregation six months later (1).

Soil and crop management practices produce significant differences in aggregation of the soil (1, 10, 23, 36, 40). Soil aggregates under four different cropping systems increased in this order: continuous corn, corn in rotation, meadow in rotation, and continuous bluegrass. Soils cropped to continuous small grain, continuous row crops, and rotations, including fallow, had only about 20 per cent as many aggregates as buffalo grass pasture (23). The amount of aggregates more than one mm. in diameter was 162 per cent higher in six virgin soils than on adjacent cultivated sites in Iowa (10). The size and distribution of soil aggregates was influenced materially by the cropping system, with the greatest number of large sized aggregates under continuous bluegrass. For crops grown in a rotation the order of aggregation was clover, oats, corn rotation, and continuous corn, respectively (3, 5, 14). This also coincides with the amount and continuity of soil organic matter supplied.

The amount of aggregates differed strikingly in Ohio under sod, mulch, and cultivation (12). The mulch showed the greatest amount of aggregates among the larger sizes. Sod resulted in about as much aggregation and the cultivated soil contained only small aggregates. The state of aggregation was in fairly close relationship to the percentage of soil organic matter, except for high aggregate formation under wheat straw mulch. The most rapid rate of aggregation occurred the first few years after land in Pennsylvania was planted to permanent sod (3). Red clover in the rotation maintained a loose, granular structure, whereas continuous corn left the soil cloddy and difficult to work.

Figure 3. This soil is located just across the fence from that in Figure 2. It had been in cultivation for a number of years. Cultivation destroyed the litter and the soil became hard and compact.

Those cropping systems which cause great reductions in aggregation are also destroyers of soil organic matter. Organic matter decreased on continuous corn plots from 3.39 per cent in 1931 to 2.86 per cent in 1942. No significant change occurred in the organic matter content of soil where bluegrass was grown continuously or where a rotation of corn, oats and clover was grown during the 12-year period (14). The aggregate state of the rotation plots was at a lower level than on the sod. Aggregation was approximately twice as high under corn in a corn, oats, meadow rotation as under continuous corn (37). It dropped rapidly when corn followed sod crops and increased when continuous corn was changed to rotation corn. A highly significant positive correlation was found between aggregation and corn yields.

Growing corn and wheat continuously in Virginia reduced both the percentage of soil aggregates and that of aggregates above one mm. in diameter (8). The addition of manure to land cropped continuously to corn or wheat increased soil aggregation temporarily. Aggrega-

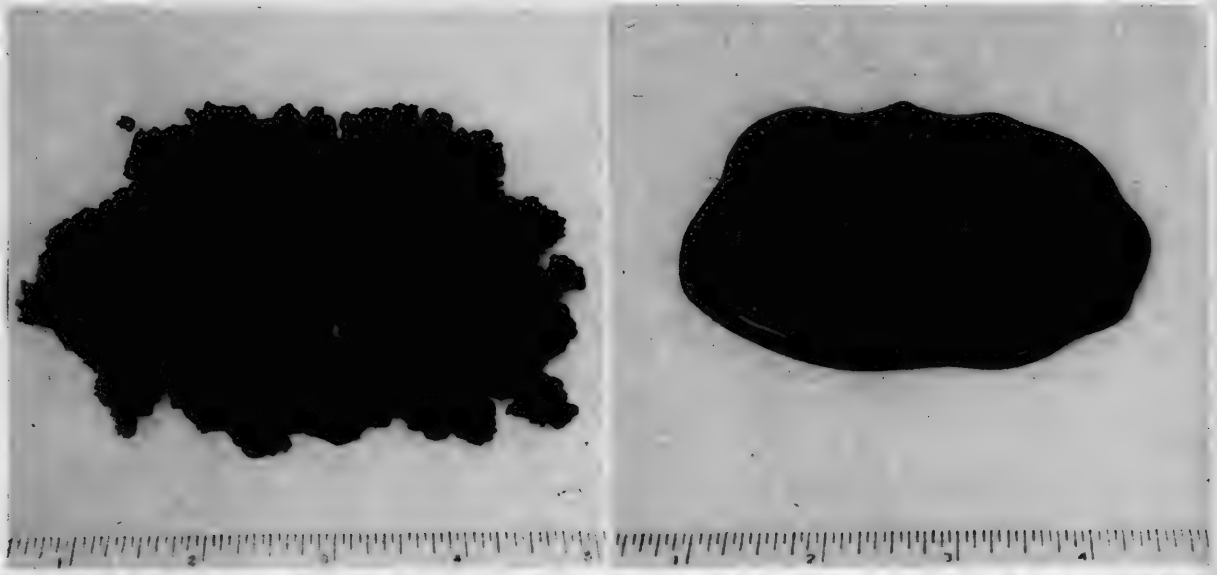

Figure 4. *Left.* This sample of virgin soil was put in a bottle of water and shaken 50 times, then dumped on paper and dried. The aggregates remained intact. It has a well developed granular structure. *Right.* This sample of soil came from the corn field that had been row cropped for a number of years. It was treated the same as the sample on the left. It is compacted and the aggregate structure has been destroyed.

tion remained the same during a 4-year rotation of corn, wheat, clover, and hay. The soil of the hay plots contained a higher percentage of aggregates exceeding one mm. in diameter. This showed that aggregates increased in size when the land was left in sod. When all crops in the rotation were fertilized or manured, the soil of the clover and hay plots had a higher percentage of soil aggregation and of aggregates exceeding one mm. in diameter than the soil under corn and wheat. Soil which had been in sod for 30 years contained more aggregates than soil cropped continuously to corn or wheat. This soil compared favorably with the soil of fertilized or manured plots of clover hay in a 4-year rotation.

After 32 years of cropping of Wooster silt loam in Ohio, the amounts of both organic carbon and nitrogen on plots of 5-year rotation experiments were found to be highly and positively correlated with the total crop production of the plots (32). The estimated annual losses of organic carbon and nitrogen from variously cropped plots are shown in Table 2.

It may be noted from Table 2 that the greatest losses of both organic carbon and nitrogen occurred with continuous cropping to corn followed in order by continuous wheat, continuous oats, the 5-year rotation, and the 3-year rotation.

Even though there were heavy losses of organic carbon and nitrogen during the years corn, wheat, and oats were grown in the rotation there was a slight increase in both items for each rotation when the rotation periods are considered as a whole. The losses sustained when these crops were grown were more than offset by gains made during the years the land was in hay. In the 5-year rotation the soil gained an average of 1.36 per cent of organic carbon and 0.64 per cent nitrogen annually when the land was in hay (mainly timothy). The gains were higher in the 3-year rotation when the land was in clover hay. They were 3.25 per cent organic carbon and 2.87 per cent nitrogen.

Table 2.—Estimated percentage annual losses from Wooster silt loam of organic carbon and nitrogen under different cropping systems for the period 1894-1925.

Cropping System	Organic carbon	Nitrogen
Continuous corn	3.12	2.97
Continuous wheat	1.44	1.56
Continuous oats	1.41	1.45
5-year rotation	0.85	1.06
3-year rotation	0.60	0.69

The organic matter content of fertility plots in Pennsylvania after 40 years of cropping is closely related to their crop yield (39). A fairly constant amount of organic matter was added per unit of crop produced irrespective of the yield per acre. On check plots rotation hay in Virginia there was a higher percentage of total soil organic matter in the one mm. aggregates than in soil from rotation check corn, wheat or clover plots (8).

The loss of organic matter is much higher the first few years after sod is put into cultivation (2). The loss is directly related to the cropping system used. Losses

of organic matter and nitrogen were less for 3- and 5-year rotations during the 20-year period 1917-1937 than for a 2-year rotation (28). The average loss of organic matter in Iowa on Clarion loam where manure was not applied was 16.2 per cent for a 2-year rotation, 11.7 per cent for a 3-year rotation, and 10.2 per cent for a 5-year rotation. The loss of nitrogen from this soil was 21.5 per cent for the 2-year rotation, 13.4 per cent for the 3-year rotation, and 10.0 per cent for the 5-year rotation. Crop residues were returned to the land in all of the rotations.

Where corn was grown continuously for 20 years on Clarion loam, the loss of organic matter amounted to 18.3 per cent (29). When grown in a 3-year rotation of corn, oats and clover the loss was reduced to 11.7 per cent. In a similar experiment on Marshall silt loam the difference was even greater. Where corn was grown continuously for 10 years, 15.6 per cent of the organic matter was lost while the loss was only 0.9 per cent where a 3-year rotation of corn, oats and clover was followed. In most cases, there were found to be highly significant correlations between the original organic matter and nitrogen contents and the losses of these constituents. The higher the original contents, the larger were the losses (28).

The aggregate condition is a fairly accurate index of soil productivity. Land planted continuously to corn for 13 years produced an average of 31.8 bushels per acre, while corn grown in a 3-year rotation averaged 54.0 bushels—an increase of over 22 bushels an acre for the rotation. The soil on the rotated plots was more highly aggregated than that on the continuous corn plots. Moreover, the difference in yield between the two treatments is rapidly increasing. In the last five years (1940-1944) the corn grown in the rotation averaged 71.2 bushels per acre while that grown continuously averaged 23.9 (29). Variously aggregated soils produced highly significant differences in the yield of wheat grown under greenhouse conditions (11). Coarsely aggregated soils produced much better growth than finely aggregated soils.

Summary

A review and analysis has been made of the literature dealing with the part organic matter and microorganisms play in soil aggregation. Organic matter is shown to be the source of the cementing substances which bind soil grains into aggregates. These cementing substances are subject to destruction by other soil organisms, consequently their effects are transitory. A continuous supply of organic matter must be available to provide replacement of those cementing substances destroyed or aggregation of the soil will deteriorate. Organic matter is more effective in the aggregation process when utilized on the surface of the ground than when turned under. It is most effective when utilized as a sod or continuous surface mulch. Those cropping systems and other soil and crop management practices which disrupt the surface supply of organic materials affect soil aggregation adversely. Both quantity and quality of organic matter are important in the aggregation process but quality is more important than quantity. A close relation exists between the amount of organic matter, the number and activity of soil microorganisms and soil aggregation. Those conditions favoring a high level of soil biological activity also favor a high state of aggregation and usually a high level of productivity. Well aggregated soils generally are more productive than poorly aggregated soils.

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From Land Exhaustion to Soil Conservation

(*Continued from page* 177)

of soil deterioration. Some of the outstanding ones were recognized by observation a century ago. They are being supplemented and perfected today by extensive research in many fields. The third idea is the use of an adequate combination of methods to conserve the soil. Several of the methods were known 100 years ago but were used very little. During the past century, both knowledge of and practice of the multiple treatments required in effective soil conservation has been increasing, especially since 1935.

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Every sizable pine and oak, or other forest tree, cut down within the memory of man! As if individual speculators were to be allowed to export the clouds out of the sky, or the stars out of the firmament, one by one. We shall be reduced to know the very crust of the earth for nutriment.

—Henry David Thoreau

Soil Fertility Reduced by Erosion And Poor Cropping Systems

RICHARD K. JACKSON

EVERY SO OFTEN, field conditions are found which provide convincing evidence of how erosion and poor cropping systems reduce soil fertility to an alarming extent. They also indicate the soil conservation and soil improvement job that must be undertaken.

Several such examples were noted in 1952 by Soil Conservation Service employees working in the Dakota sandstone and shale area that lies in the McPherson, Saline and Ottawa soil conservation districts in Kansas and extends northward into Nebraska.

Since moisture supplies and climatic conditions in 1952 were ideal for wheat production, the differences can be said to be traceable to the depth of topsoil and the amounts of organic matter, nitrogen and phosphorous in the soil.

The Dakota sandstone and shale soils are old geologically. They have been leached to the extent that calcium and phosphorous supplies are so low that legume stands are hard to establish. Much of the topsoil has been lost through erosion, resulting in low organic matter and nitrogen supplies. Common cropping practices have been to grow wheat or sorghum continuously. Sorghum fodder that is not fed during the winter is burned.

Opportunity for the field observations resulted largely from accident, when farmers' fertilizer drills did not do a uniform job. The fields were visited in May and June.

The intent of Herbert Macklin, six miles northeast of Canton, Kansas, was to apply 100 pounds of 13-39-0 fertilizer an acre along with his wheat, but one side of the fertilizer drill did not work. The result was alternate strips of fertilized and unfertilized grain. Growth was much less where no fertilizer had been applied.

The slope of this field is only four per cent, but nearly three-fourths of the topsoil has been lost through erosion.

W. Lehner, four miles south of Canton, has a field of which part has been in wheat continuously for 50 years and part was broken out of native grass 20 years ago. The slope is four per cent. Half the topsoil has been lost through erosion from the older part and one-fourth of the topsoil from the newer part.

Lehner set the fertilizer drill to give this land 45 pounds of treble superphosphate an acre, but his drill didn't do a uniform job. On the older part of the field, the addition of phosphorous alone failed to bring much increase in yield. There was too little organic matter and nitrogen. On the newer part, with more topsoil remaining, wheat in the fertilized strips made considerably better growth than wheat in the unfertilized strips.

Figure 1. This is a view showing the difference in growth between fertilized and unfertilized wheat in 1952 at the Herbert Macklin place near Canton, Kansas.

Not only were there more grain heads on the fertilized strips in the newer part of the field, but the heads were also 2½ times as long as the grain heads on the older part.

On the demonstration farm operated by the Saline Soil Conservation District, part of a field received both nitrogen and phosphorous fertilizer and the growth was good. Part received only phosphorous and the response was slight. The slope is four per cent and six inches of topsoil remain. This farm is operated by the district with the aid of the State Experiment Station, county agent, and Soil Conservation Service.

Even the bottomlands showed fertility needs. An example is a field in the Schippel estate east of Salina, which has a nearly level surface. The whole field was given nitrogen in the form of anhydrous ammonia for the 1951 crop. The application was repeated for the 1952 crop, with the exception of a strip that was skipped purposely. There was considerably greater growth on the part that received anhydrous ammonia both years.

The topsoil is 14 inches thick on Roy Yoder's wheat field, southwest of McPherson, and sweetclover had been

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grown there two years before the 1952 crop was seeded. Treble superphosphate was drilled with the wheat at the rate of 85 pounds an acre. Ample supplies of organic matter, nitrogen, phosphorous and moisture in a thick topsoil produced just over 40 bushels of wheat an acre.

These observations are supported by results on soil testing by the Saline County agricultural agent. He received 363 soil samples for testing during the year ended June 30, 1952.

Of the soil samples, 156 showed only a very low amount of available phosphorous an acre and 97 samples showed only moderate amounts. A need for lime was evident in 135 of the samples, while others indicated that small amounts of lime would aid in assuring good legume stands. No sample contained as much as three per cent of organic matter, and the amount was less than one per cent in 41 samples. The tests indicated the potassium supplies are ample at present.

Previously, in 1947 and 1948, the county agent and Soil Conservation Service had cooperated with two farmers in the use of soil amendments in establishing sweetclover. Both farms have deep, loamy soils developed from the Dakota material.

Figure 2. Wheat on the left came from land that had been in wheat 20 years since it was broken out of nature sod while that on the right came from land that had been in wheat for about 50 years. All of this land is in the same field and all received the same amount of treble superphosphate. Nitrogen supplies were very low in the older part of the field, so the response to the use of treble superphosphate was slight.

Figure 3. This is on the demonstration farm operated by the Saline County Soil Conservation District. The part of the field in the foreground received only phosphate fertilizer and the response was slight. The part in the back of the picture also received nitrogen and the response was good.

Stands were thin and yields were only 400 pounds of sweetclover hay an acre where no soil amendments were added. Where 65 pounds of treble superphosphate was drilled with the seed, the yield was 1,700 pounds of hay an acre where 400 pounds of finely ground limestone was drilled in the rows. But where the lime and treble superphosphate were used together, the hay yield was 4,000 pounds an acre.

These observations point to the seriousness of the land deterioration that has taken place. The need for conservation farming to control erosion, improve the soil structure and fertility, and replenish the supplies of organic matter is pressing. This includes both mechanical measures to control erosion and crop rotations and fertilization programs for soil improvement.

A nation deprived of liberty may win it, a nation divided may re-unite, but a nation whose national resources are destroyed must inevitably pay the penalty of poverty, degradation and decay.

—Gifford Pinchot

The strength of our nation is due to the continent of North America. It has molded us, nourished us, fed its abundant vitality into our veins. We are its children, lost and homeless without its strong arms about us. Shall we destroy it?

—Stuart Chase

Soil Conservation in Israel

YEHUDA LOWE

The aim of soil conservation is to make the best use of the natural resources of any given country with a view to preserve and to increase its fertility. This goal cannot easily be combined with the tendency of increasing the food production within the shortest possible time, as it is necessary for Israel with the rapidly growing demand for food and its scarcity of foreign currency. A proper solution must be found between excessive use of the land which leads to the exhaustion of its fertility on the one hand and the most orthodox methods of soil conservation which sometimes are incompatible with the pressing needs on the other. Between these two extremes a careful decision has to be made based upon the optimum land use in the long run.

ISRAEL IS A COUNTRY with sub-tropical climate; that means that the rainfall is concentrated in a rather short period, roughly from the middle of November until the end of April, whereas throughout the summer there is no rainfall. The quantity of rain varies widely between different regions, amounting to about 18 inches in the Coastal Plain, up to 32 inches in the north and down to less than two inches in the extreme south. During the 20 to 60 rainy days there are usually heavy rain storms which exert a devastating influence on the bare hillsides. They carry with them the top soil and wash it into the sea. Within a few hours the numerous dried-out rivulets, so-called wadis, change into rapid streams which contribute to the depletion of the soil. In such a country, soil conservation is a must and has much more far-reaching effect on agriculture than under moderate climatic conditions.

Israel stretches along the Mediterranean, and on the border of the long coastal line there are sand dunes of different width. Behind them extends the undulated maritime plain which goes over into a hilly country and gradually rises to mountains which form the border towards Jordania on the east and towards Syria in the north. These mountains are steep and slope toward the Jordan rift which, incidentally, forms the lowest point on earth, varying between 700 feet and, at the Dead Sea, 1300 feet *below* sea level. In the north, the country widens into inner valleys of rather high fertility; in the south the land forms a huge triangle with the apex at the Gulf of Aqaba. This district, the so-called Negev, comprising more than half of the total area has, starting from the north, less than four inches of rainfall, diminishing to less than two inches at the southern tip. This area of the desert is almost uninhabited due to the extreme low rainfall and to the lack of any rivers or underground water sources.

Dr. Yehuda Lowe is associated with the Government of Israel. He has done much in helping his country to restore the fertility of lands that were once badly eroded and depleted. The Government of Israel recently established a Soil Conservation Service to cope with land use, soil erosion control, water conservation and other related problems.

For an American it is not easy to grasp the smallness of the country. The total area measures no more than 8,000 square miles, about the same size as Massachusetts, whereas the northern inhabited district comprises only 4,000 square miles, half of which can be cropped. That leads us to the conclusion that the cropland area of Israel is equal to the size of Delaware.

Man is Responsible for Soil Erosion

The eroded hillsides, bare of all trees and with hardly any soil on them, give the impression of a country which does not seem suitable for any human population and sharply contrasts with the description of the Holy Land in the Bible as the "Land of milk and honey." Two facts have to be borne in mind for explaining the contradiction. First that the present state of decay does not mean in itself that at Biblical times the country had the same desolated character. Second, before taking into account that at former times much more was cultivated than today, our notions about a fertile country do not coincide with the conception of a nomad coming from the Arabian desert. For him even a moderately cultivated area must seem a Paradise in comparison with desert wasteland. *But let me remark here that man, not nature, is primarily responsible for soil erosion in Israel and for that in all the surrounding countries as well.* We know that the once wooded hills with age-old terraces carefully planted with fruit trees and vineyards were exposed to erosion by felling the trees and neglecting the terraces. Especially during recent times, in World War I, the timber of the forests which prevented soil erosion was recklessly used for building railroads for military purposes.

In addition, over-grazing was a common practice and the biggest menace were the goats. The sparse natural vegetation could not recover being constantly bitten off. Instead of calling the Arab "the son of the desert" one could aptly call him "the father of the desert" because his negligence was the main cause for soil erosion which played havoc with the once fertile land.

Jewish colonization in Palestine was tantamount to soil conservation from the start. Jewish pioneers set out

with draining the swamps in the inner valleys which heretofore not only prevented any utilization of the land but even formed the malicious source of malaria.

Building of drainage canals and planting of eucalyptus helped to transform these once shunned areas into fertile regions. Today these same districts are densely settled by a healthy population engaged in modern agriculture. Gradually one district after the other was taken up and reclaimed. There remains a rather large swamp north of the Huleh Lake which is now in the process of being drained. This again will add an important area for further colonization.

Hand in hand with drainage went aforestation undertaken by the Jewish National Fund. Until the creation of the State progress in this work was rather slow. Nevertheless an area of more than 10,000 acres, spread all over the country, was reforested. This helped to improve the climate and to prevent further erosion. As against the eight million trees planted within more than 30 preceding years, the program for the next year provides for doubling this number. In this way we can hope that after some years all the hills which are unfit for any better use again will be crowned by forests. It will, however, take many years until these trees will be full grown.

Preservation of soil and water in itself is not enough for colonizing a sub-tropical country like Israel with a population of comparatively high standard of living. Already there are ten times as many people per square mile in Israel as in the United States. Such a high density of population could only be reached by making use of available water resources for irrigation purposes.

Coming by airplane over the Mediterranean one can see citrus plantations all over the coastal plain of Israel, stretching from Gaza in the south almost to Haifa in the north. The introduction of citrus by Jewish colonists was made possible only by irrigation drawing upon underground water.

Conservation Efforts are Productive

Great strides were made in developing irrigation as a means to produce green forage, vegetables and potatoes. Wherever a small river was available or water could be tapped with the help of a well it was done. Even the brackish water found in rivers in some places is used for carp breeding in artificial ponds which give a surprisingly high yield of around 1600 pounds of fish per acre a year. At the northern shore of the Dead Sea a successful attempt was made to wash out the salts from the soil by applying large quantities of water from the Jordan River in order to make the land cultivable. The film "House in the Desert" which some of the JOURNAL readers may have seen, shows what stubbornness and faith in the impossible have achieved in this isolated spot. This settlement was destroyed during the War of Independence.

From the beginning modern methods for guarding and improving the fertility of the soil were applied. This is the more important in irrigated agriculture in which on one and the same area usually one and one-half yields are grown in one year. We therefore introduced from the beginning carefully planned crop rotations, alternating legumes and root crops with cereals. Regular organic manuring is applied in addition to chemical fertilizers. Since stable feeding of dairy cows tends to increase the production of organic manure, it is the common form of keeping milk-cows, as large production of organic manure is regarded even as more important than labor-saving methods such as pasturing.

Also in respect of utilizing the water resources of the country we only stand at the beginning. Professor Lowdermilk was the first who envisaged a plan which he named the Jordan Valley Authority in reference to the multi-purpose project of TVA. Working according to this idea, first class American engineers such as Bashore, Savage, Hays and Cotton, together with our own experts, prepared the so-called Master Scheme of Water and Hydroelectric Power for Israel, a rough draft of which is indicated on the map.

There is a considerable surplus of water in the extreme north of the country which has to be carried all the way down into the south in order to make good use of it.

Transferring the water all through the country would allow to integrate into this scheme the numerous small rivers and rivulets which so far carry their water into the sea, especially in short winter floods, without any use.

Without going into detail it suffices to say that the execution of this plan could increase the irrigated area six to eight times over the present one. This means that one-half to two-thirds of the total cultivable land could be irrigated. Bearing in mind that each acre of irrigated land produces roughly four to six times as much crop values than unirrigated, one can easily understand the economic importance of this undertaking. There are no technical difficulties standing in the way of implementation of this project which cannot be easily overcome with the methods and the knowledge of nowadays. The only impediment is lack of capital in general and foreign currency in particular.

Part of this plan is the utilization of the difference in level between the Mediterranean and the Dead Sea for the developing of hydroelectric power. The 1300 feet difference can be converted into the generation of power to the extent of one and one-half times as much as the total present consumption of electricity throughout the

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Book Reviews

FOREST RESOURCES OF MONTANA. *By* S. Blair Hutchison *and* Paul D. Kemp, *Northern Rocky Mountain Forest and Range Experiment Station. U. S. Forest Service. Forest Resources Report No. 5, 1952. U. S. Gov't. Printing Office. 55 cents.*

Economists, businessmen, foresters, conservationists, public officials, and others concerned with the future economic life and welfare of Montana will find much information in this report worthy of their careful consideration. It's easy to read style, liberal use of pictures, graphs, and maps, and orderly presentation invite continued reading of its 55 pages of text and 20 pages of appendix.

The report is one of a series on the forest resources of the United States being prepared by the Forest Service as authorized by the Clark-McNary Forest Research Act of 1928. Ten years of field survey work in the public and private timber lands of Montana provided the basic data used in its compilation. Completion of the work was delayed by World War II.

There are answers to many pertinent questions about Montana's forests in the report. The state of Montana occupies an area of 93,642,000 acres of which one fourth is forest. More than one half of the forest lies west of the continental divide in one sixth of the state. Seventy per cent of 15,756,000 acres are suitable for commercial timber and contain 56 billion board feet of timber or about 3½ per cent of the national total. Seventy-six per cent of the total forest and 69 per cent of the commercial forest is publicly owned.

The growth rate of Montana's forests are unsatisfactory due to lack of restocking, improvement cuttings, high per cent of decadent stands, and high mortality losses from fire, insects, and other natural causes. Recent improvement in fire protection is reducing this loss but insect damage will continue until a larger percentage of mature trees are harvested.

Except in isolated cases the timber cut has been too low on most species except Ponderosa Pine. Greater utilization of the timber resources is needed to balance the economy of the state. Access roads, more diversified industries using forest products, and better transportation to markets will increase timber utilization.

Besides timber values the forests offer major contributions to the state's economy in water, recreation, and forage values. Significant is the finding of this study that the timber producing capacity of the commercial forest is far greater than many people realized.

The report concludes by stating that the success of Montana in taking advantage of the opportunity to utilize its forest resources depends on two facts: First is the factor of economic feasibility mainly dependent on the distance to a market for forest products; and second whether an aggressive forest protection, development, and management job can be agreed on by private landowners, state and federal agencies, and the public. The leadership of the people of Montana will determine the extent to which the forest resources can contribute to the welfare of the state.

—H. A. Hopper, *Lafayette, California*

INTRODUCTION TO ECONOMICS FOR AGRICULTURE. *By* John D. Black, *Henry Lee Professor of Economics, Harvard University. The Macmillan Company, 60 Fifth Avenue, New York 11. 1953. 727 pages. $6.00.*

This book is intended primarily as a college textbook but will be of much help to those working in the field of agriculture who desire an understanding of the general principles of economics as well as an understanding of the economics of agriculture. Its objective as described in its preface is: "This book has one clear-cut objective —to give an agricultural college student, or educated farmer or his equivalent, exactly that understanding of economics which he or she needs in order to function effectively and live happily in the world of today. This economics is partly the economics of agriculture and rural living and partly that of the general economy in which agriculture has its setting."

For the agricultural-minded this book has much more to offer than the usual book on the general principles of economics since it dwells less on the refinements of economic principles and pays more attention to the economics of production, consumption, and marketing and factual background about the agricultural economy.

Nine parts are included in this book: 1. Orientation, 2. Production, 3. Consumption, 4. Commodity Distribution, 5. Money, Banking and Credit, 6. Income and Its Distribution, 7. Land Economics, 8. International Economics and 9. Public Economics.

The text points out that economics is an integrating science, bringing together in various relationships the facts and principles of sciences relating to matter, man, and society. Dr. Black emphasizes that the objective of the science of economics, in agriculture as in any other field, is to provide a basis for the economizing of resources, that is, for using them in such a way as to get the most out of them. The resources to be considered are (1) natural resources of all kinds; (2) human resources; and (3) capital goods.

Dr. Black has written a comprehensive text, covering nine parts, 45 chapters, and 719 pages. It contains considerable historical information on the subject and draws from foreign countries as well as the United States. A wide variety of illustrations covering many situations in

the United States and abroad are used. Many tables, charts, and graphs are also included with a wide array of references. Materials from Dr. Black's earlier books and writings are well integrated into this text. Unfortunately, not all of the tables and charts are brought up to date, some series of data carrying only through 1940. In general, the author has done an excellent job of drawing from his many other writings and the writings he has done with others to illuminate and emphasize his treatise.

Dr. Black clearly points out a factor that many conservationists have experienced: "In general, the 'common sense' of the farmers keeps them from accepting the advice of the technological perfectionists; the difficulty is that it over protects them and keeps them from adopting recommendations that would yield handsome gains. Only by making sure that their advice is economically sound can technicians gradually win the full confidence of farmers."

In Part 3, under Consumption, is a challenge for conservationists. It is pointed out that food supply and standards of living will depend on the rate of increase in the arts. The increase in the arts will depend on the kind of management given to the land, the level of productivity at which it is maintained, and the returns it yields per man-day of current labor and labor stored up in capital.

The author states that "the farm is the most universal of all economic units. As an economic unit it is a combination of a business firm and a household." The book is a treatise on private economics as well as public economics. It analyzes the economics of the individual farm and of the individual marketing firm as well as the economics of national production, marketing, and credit programs.

Part 8, Land Economics, states that "usually there are ways of using crop and pasture land that increase net returns and raise productivity at the same time." Based on 18 years of conservation research study, this reviewer can say "Amen!" to this statement. It is doubtful if Dr. Black will receive universal agreement as he goes on to state "and this country has made much more progress in adopting such uses on farm lands than on forests, and a continuation of the progress made along these lines in the last ten years will conserve all the productivity of the farm lands of this country that is in prospect of being needed."

Dr. Black's detailed but realistic and interesting presentation in this book should make economics interesting to an agriculture student. It should help the conservationist and other agricultural workers outside the field of agricultural economics to understand better the intricate relationship of most all phases of economics and of agriculture.

—E. L. SAUER, *Champaign, Illinois*

THE ECONOMICS OF CONSERVATION. *By* J. G. CRAWFORD. *Bureau of Agricultural Economics, Department of Commerce and Agriculture, Canberra, A. C. T. 59 pages. 1952.*

The overriding objective of increased output during the early development of a nation's virgin natural resources seems inevitably to produce an atmosphere of indifference to resource spoliation and misuse. At least the opening-up of Australia and the United States show striking parallels in resource misuse, and in both countries virtually complete alienation of the "public domain" had occurred before effective curbs for various exploitative practices were seriously considered.

Mr. J. G. Crawford, head of the Australian Bureau of Agricultural Economics, has traced very briefly but cogently Australia's major land problems from their inception to the present, and has indicated the obstacles that must be overcome to correct soil abuse and raise the level of agricultural productivity. Although Australia faces some unique problems, such as a voracious rabbit population, Crawford's discussion of over-grazing of pasture land and exploitative wheat farming with minor alteration might pass as descriptive of American practices in some regions.

Australia is a large continent with a small population of somewhat less than ten million persons, but it is an important source of world food and wool. If Australia is to maintain its position in the world food and fiber market, as well as meet the domestic requirements of its growing population, conservation of soil resources and increased land productivity must be achieved. Obstacles to attaining these objectives are the small size of the average farm, which discourages crop rotation, the shortages of labor and equipment, which have curtailed conservation improvements and limited farm output, and the long-run deficiency in fertilizer supply. On the credit side are a growing awareness of the need for conservation and a "social climate" that is generally favorable to the introduction of conservation measures. For example, income tax deducitons are allowable for expenditures on almost every significant investment in pasture improvement, water conservation, and soil erosion control.

In addition to the discussion of soil conservation in the body of the monograph, five supplementary appendices provide factual material on such topics as rotational practices on wheat farms, the effect upon farm income of soil conservation practices, and the like. In a very limited number of pages Mr. Crawford has presented an interesting description and a balanced analysis of Australia's soil conservation problems.

—L. G. HINES, *Hanover, New Hampshire*

SOIL CONSERVATION. U. S. NAVY, *Tech. Publ. Navdocks TP-Pw-5. Washington, D. C. 82 pages, processed. 1953.*

The frontiers of soil conservation are pushed into new fields with the appearance of the first publication of the U. S. Navy dealing with erosion on naval installations.

A few years ago such a publication from this source would have seemed incongruous. But the acquisition of extensive land holdings by the Navy during and since World War II make the subject pertinent and vital. With the extension of its engineering works to many inland communities, soil conservation and erosion control practices have assumed such importance that the Bureau of Yards and Docks has established an office to provide technical guidance on this subject. This attractive pamphlet is a major accomplishment of this new office.

While dealing specifically with the problems peculiar to the location, design, and maintenance of naval facilities, the handbook is notable for its comprehensive and concise coverage of the varied field of erosion control.

The section on surveys gives specific guides to making conservation (i.e., soil), woodland, grassland, topographic, hydrologic, and geological surveys. A fresh and highly utilitarian approach to soil surveys is presented, and useful guides to estimating runoff are provided for use in hydrologic surveys. The information should be equally useful to technicians outside the Navy.

The section on erosion-control practices is equally comprehensive and well-proportioned. It is liberally illustrated with charts and tables. Those on irrigation should be especially helpful.

Presumably the booklet is intended for use within the Bureau of Yards and Docks, but copies will be highly prized by those outside the bureau who obtain them.

—BEN OSBORN, *Midland, Texas*

Four New Books Added to "True-To-Life" Series

WOODY WOODCOCK, MAC MALLARD, WILLIE WHITETAIL, AL ALLIGATOR. *By.* R. W. ESCHMEYER. *Illustrated. Fisherman Press, Inc., Oxford, Ohio. Paper-bound 50c; Deluxe cloth $1.00. 1953.*

Woody the Woodcock's life in the woodlot is portrayed through a series of activities—obtaining food, swimming, migrating, performing his mating dance, and establishing his own singing area. Into this narrative are woven interesting bits of information about Woody's unusual bill, his appetite for earthworms, and his protective coloring. The reader learns how young woodcocks are located by the help of hunting dogs, and how they are banded. A hunter gives logical reasons why some wildlife should be killed in moderation, but why a true sportsman does not "kill his limit."

Attractive illustrations by Francis W. Davis in rich woodsy brown color are found on every page. These do much to add to the understanding of the text.

Sentences are short. Vocabulary is simple. The format and content of the book should lead a child to read it the first time. Undoubtedly he will re-read it numerous times to get all the fine information it contains.

Mac Mallard is an account of the doings of his family who live on a 5,000 acre marsh. Here, waterfowl are "herded" into wire traps, netted, and banded. The reader follows in imagination Mac Mallard's first migratory flight, noting the hazards encountered with hunters and their dogs. He learns about decoys and duck blinds, illegal duck hunting, the work of game wardens, and how ducks are killed by lead poisoning. Pertinent facts are inserted about siltation and its affect upon fish and waterfowl.

Young readers can hardly fail to acquire a feeling of kinship with the Mallard family after reading Mac Mallard and reveling in the colorful, appealing illustrations by Francis W. Davis which closely follow the text.

Willie Whitetail is born in a game refuge. The account of his life there reveals numerous sidelights on the "deer question" which both children and adults need to know. Discussed in simple terms are these: Why does in a refuge may have fewer and smaller fawns; why fewer hares and squirrels may be seen in a refuge; why deer may starve when they are "protected"; and whether general deer hunting should be allowed or only bucks should be killed.

In reading Willie Whitetail, a child's natural love for deer will be augmented by understanding what motivates true conservationists to advocate certain actions relating to the maintenance of deer herds, both in and outside of deer refuges.

Illustrations by Roy K. Wills on every page are vivid and realistic and tell a story in themselves.

Al Alligator tells how alligators hatch, find food, build nests, and fight—the reader gets a fascinating glimpse of animal life in a large swamp in Florida. A hunter explains how alligators are located, killed, and skinned. The story of Okefenokee Swamp is told, from its early beginnings to its being taken over as a National Wildlife Refuge by our government.

Endpapers and cover are eye-arresting. Children will

be drawn to study the attractive green and white illustrations by Roy K. Wills.

—IVAH GREEN, *Crete, Nebraska*

Wells and Bore-Holes for Water Supply. *By* J. E. DUMBLETON. *The Technical Press Ltd., London, England. 1953. 137 pages. 17/6d.*

The author of this excellent book emphasizes the importance of boring for underground reservoirs as the need of unrestricted supplies of water increases. In so doing, he discusses in detail the construction of different types of wells in both rural and urban areas; also various methods of well boring used in England.

The properties of water and water analysis and purification are presented in another section of the book. It is easy to read and contains many very fine line drawings of equipment and cross sections of underground water bearing strata.

Report of the Natural Resources Board—*Southern Rhodesia. By* P. GORDON DEEDES.. *Rhodesian Printing and Publishing Company, Salisbury. 1953. 26 pages.*

This report, for the year ended 1952, covers the various resource development activities of the board including land, water, minerals, game and fish, legislation and other related administrative matters.

Washing Our Water: Your Job And Mine. *By* HELEN B. WOODWARD. *Public Affairs Committee, Inc., 22 East 38th Street, New York 16, New York. 32 pages. 1953. 25c.*

The unprecedented growth of industry, together with our expanding cities, has burdened many of our rivers beyond their capacity to flush away waste. The seriousness of this, as it affects the health and general welfare of people and industry alike, is the subject of this exciting new pamphlet.

Forestry and Its Career Opportunities. *By* HARDY L. SHIRLEY. *McGraw-Hill Book Company, New York. 492 pages. Illustrated. 1952. $6.50.*

This book is designed for students who plan to follow forestry as a career. It lays special emphasis on career opportunities by giving a broad historical background of forestry in all its aspects. The book also sketches problems which may concern foresters in the years ahead.

Some Plant-Soil-Water Relations in Watershed Management. *By* LEON LASSEN, HOWARD W. LULL AND BERNARD FRANK. *U. S. Forest Service, Washington 25, D. C. Circular N.910. 64 pages. 20 cents. 1952.*

Waves and Tides. *By* R. C. H. RUSSELL AND D. H. MACMILLAN. *Philosophical Library, New York. 348 pages including 100 line drawings and 17 photographs. $6.00. 1953.*

New Conservation Film

Birds of the Prairie. *Color. Running time 10 minutes. Minneapolis-Moline Co., Minneapolis 1, Minnesota.*

This color film has as its locale on the western prairies when flowers are in bloom and birds are nesting. Blackbirds perch on the rushes, while willets and godwits fly overhead, and long-legged avocets incubate their eggs until finally the young avocets cut their way out of the shells. A longbilled curlew, largest of all North American shore-birds, puts on her amazing broken wing act to lure an intruder away from her eggs. Graceful common and black terns fly in and settle on their eggs, while on an island in a prairie lake thousands of trim white gulls and hundreds of sedate white pelicans go about the business of rearing their families. The film demonstrates that birds are extremely interesting and infinitely beautiful and that they constitute a resource we should cherish and guard as an important part of our American heritage.

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International Grand Prize To Missouri Quail Film

"Bobwhite Through the Year," a motion picture produced by the Missouri Conservation Commission and filmed by the commission's artist-biologist, Charles W. Schwartz, was awarded the "CONI Grand Medal" at the international sport-film festival held this spring at Cortina d'Ampezzo, Italy.

A medal and certificate go with the award. About 100 films, embracing many kinds of sports with emphasis this year on winter sports, were entered in the competition. A total of 16 prizes were awarded. Highest honor was the Medal of the Presidency, followed immediately by six CONI Grand Medals considered equal in importance. "Bobwhite Through the Year" was adjudged best in the field of hunting and the best for color photography.

The initials CONI stand for the Italian words that mean "Italian National Committee on Olympics." This is the group which sponsors the film festival.

The Missouri film depicts the life history of the bobwhite quail, beginning with the covey break-up in spring and following a pair of birds and their brood through summer, fall and winter. Farmers and sportsmen are shown the natural hazards of a quail's existence and what may be done on the land to increase bird populations. Excellent bird-dog performance and hunting scenes are included.

Work Improvement Suggestion

Hubert R. Marshall, John A. Hammons, and A. L. Hutchins of the Fort Sumner and Clovis work units in New Mexico have put their ingenuity to work and come up with a work improvement suggestion of a very practical nature.

They developed a device for driving grade stakes which consists of a metal sleeve four inches long which fits snugly over the end of grade stake for a distance of three inches. An iron bar about a foot long is welded to the upper part of the sleeve extending down into the sleeve about an inch. This device prevents shattering of the upper end of the grade stake and also permits stakes to be driven below ground level without difficulty.

National Crop, Soil Societies to Meet in Dallas Nov. 16-20

The 1953 annual meetings of the American Society of Agronomy and the Soil Science Society of America will be held November 16-20 at Dallas, Texas, according to an announcement from officials of the two gorups.

An estimated 250 papers on new developments in crops and soils will be presented during the course of the meetings. The programs are open to anyone concerned with crop production and soil problems, and interested persons are invited to attend.

H. E. Myers, associate director of the Kansas Agricultural Experiment Station, Manhattan, Kansas, is president of the American Society of Agronomy. Eric Winters, soil scientist with the Tennessee Valley Authority, Knoxville, Tennessee, is president of the Soil Science Society of America.

Both societies consist of specialists in crop and soil problems. The combined membership of 2200 includes representatives from commercial and industrial organizations, agricultural colleges, and federal and state agencies.

Contestants From Fourteen States Take Part in Land Judging Program

The second National Land Judging contest brought 2,000 contestants and observers from 14 states to Oklahoma City April 30 to May 1 with 812 contestants competing for $1,000 in prizes offered by the sponsor, WKY, WKY-TV radio and TV station. A Land Appreciation Training school preceded the contest.

Contestants came from New Mexico, Nebraska, West Virginia, Kansas, Missouri, Iowa, Illinois, Indiana, Ohio, New York, Florida, Arkansas, Texas and Oklahoma.

The Land Judging Contest is an outgrowth of the annual 4-H and FFA schools and contests held at Red Plains Conservation Experiment Station near Guthrie, Okla. It is based upon skills in identifying soil characteristics and determining the best treatment and use for the land.

First Place winners in four classifications were: Bartlesville, Oklahoma, 4-H Division; Buffalo, Oklahoma, FFA Division; Sidney Spore, Kildare, Oklahoma, Adult Division, and Oklahoma A & M College, Collegiate Division. Awards also were made to second and third place contestants.

Approximately 20 women and high school-age girls competed against men and boys in the land judging events, while others offered encouragement to their menfolk.

The idea is spreading. It is estimated 30 states are using some form of land appreciation training school and judging contest. The generally-accepted score card includes these points: *One*—texture of topsoil; *two*—permeability of subsoil; *three*—depth of soil; *four*—erosion; *five*—slope, and *six*—surface drainage. There are variations among the states, some including soil color on the card. These characteristics taken together determine the Land Capability Class and land is treated according to its classification.

Edd Roberts, extension soil conservationist, asked by a farmer-banker just what land judging is, gave this answer:

"Land judging is making a decision on these things: (1) how much clay in the soil; (2) how tough is the subsoil; (3) how deep is the topsoil; (4) what is the slope of the land; (5) how extensive is erosion; (6) what are surface drainage conditions, and (7) how good is the land? Conservation of the soil and water helps to perpetuate the land, to improve it, conserve it and make farming profitable."

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2. **Scientific terms which the average conservationist needs to know or is likely to find in soil and water conservation literature.**
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Professional workers in soil and water conservation and related fields will want copies for reference purposes; also students of agriculture, agricultural libraries of high schools, colleges and industries. Vocational Agriculture Instructors, County Agents, Extension Specialists, members of soils departments, experiment stations and college instructors will find the Soil and Water Conservation Glossary useful.

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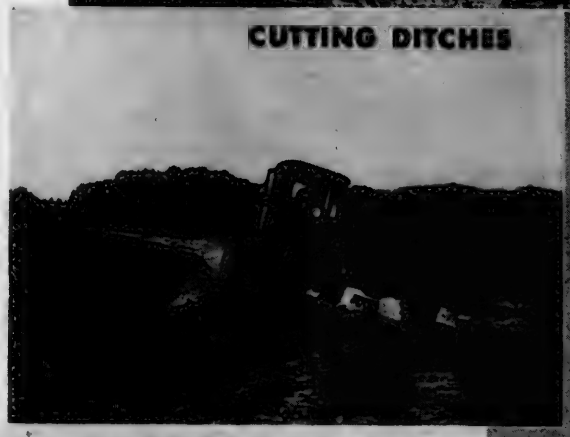

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Soil Conservation in Israel

(*Continued from page* 188)

country. At present, Israel depends entirely on imported oil as the only source of power production.

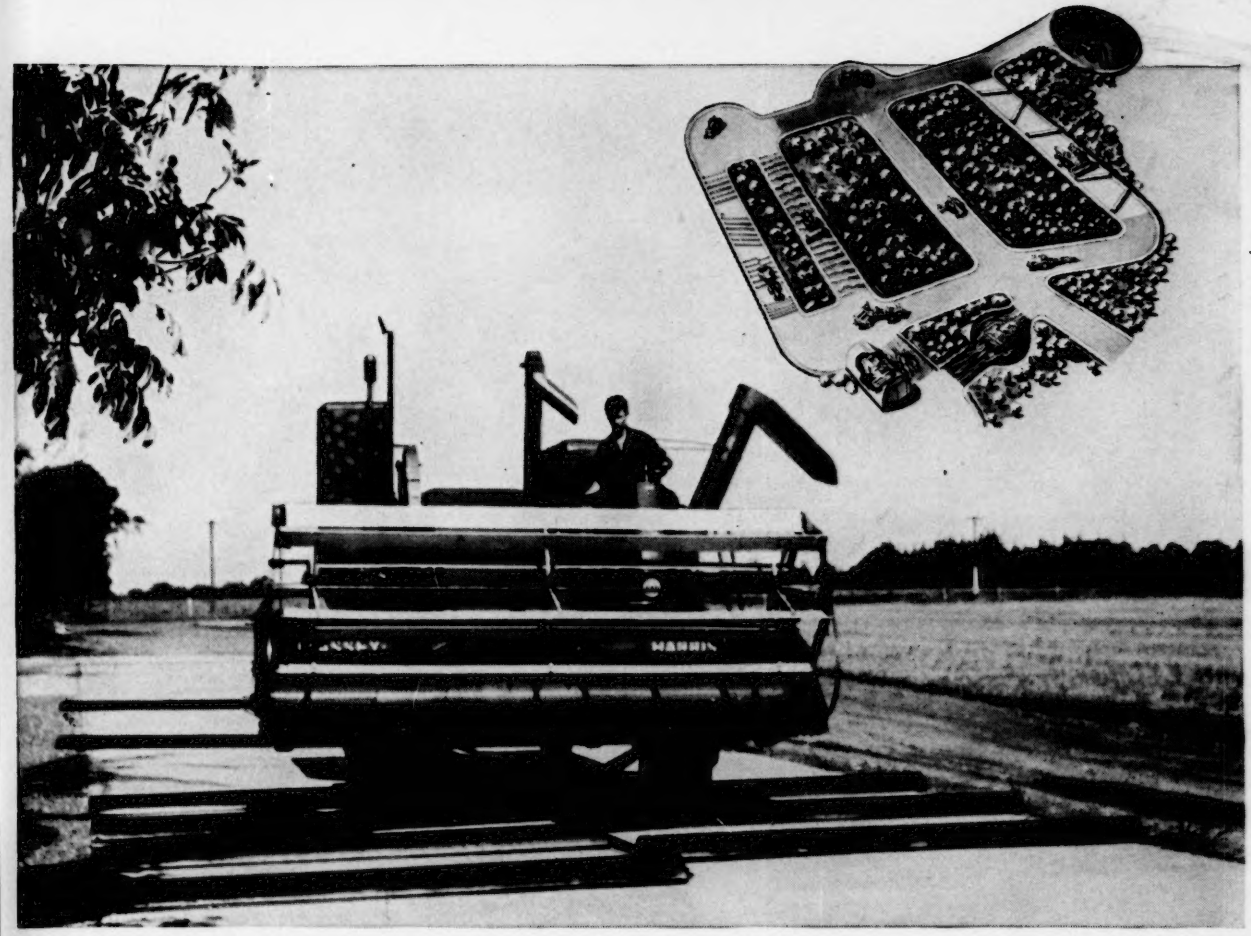
Our conception of soil conservation methods do not exhaust themselves in major plans for the future but also in everyday methods of each and every farm, especially in regions where undulating land prevails. We reintroduced the age-old method of planting fruit trees on terraces, built around the slopes, and we applied modern contour plowing wherever necessary.

Among the many, one settlement in the south stands out as a demonstration for soil conservation methods at their best. In Dr. Lowdermilk's opinion the work performed here by one of his ardent admirers, Mr. Gil, the chief of our Soil Conservation Division, offers a masterpiece of well-designed and thoroughly carried out soil conservation.

Special tasks await the soil conservationist in the Negev. This huge uninhabited desert country does not seem fit for any colonization at all. Yet the discovery deep in the Negev of many wadis whose sides "had been terraced from bottom to top, of numerous cisterns to catch the run-off of rain water, and dozens of earth dams," was revealed by Dr. Nelson Glueck. . . . "This effort of man to bring fruitfulness to what is now a howling wilderness was made by the Nabateans, who during the first century of the Common Era knew better than any other people in this part of the world during the last 6,000 to 8,000 years, how to save water."

"Their example is now being followed by Israel. What has been, can be done again. The Negev was not and need not be a wilderness."

Israel is still far from having completed its goal of redeeming the ancient homeland and making it once more "a land of milk and honey" for a striving population of a high standard of living. But the achievements of the past are ample proof of progress in the right direction and are encouraging for the larger schemes to be undertaken in the future. Their main importance lies in the fact that they teach a lesson of what can be done under adverse conditions of nature, not only in Israel proper, but throughout the Middle East.



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Often these soil materials settle out in low spots—as layers of mud—cracking under the burning sun. This caked mud will grow no crop this year, unless it's a late crop of noxious weeds. Caked mud like this is a story of waste, a story of failure to hold rainwater in the fields.

For those with leaky fences, soil conservation districts have an answer—correct land use, along with a complete soil conservation plan for the farm.

Farming by a plan is not really complicated. It's just good management applied to the soil. And the soil deserves to be well managed, for it is the farmer's storehouse of wealth. It's his bank—where he can deposit and maintain soil productivity, to be called upon when needed.

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JOHN DEERE, MOLINE, ILLINOIS